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Monitoring Heat Stress and Circadian Rhythm in Urban Agglomerations

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In recent years, heat waves were found to commence earlier in the year and to last longer, locally accompanied by heavy rain and varying levels of humidity. These temperatures exceed the human comfort interval, and must be looked upon as extreme strain, since the body's heat-defensive system is constantly active. Full recovery during sleep is almost impossible under these circumstances, causing significant increases in morbidity and mortality. While the link the statistical link between heat stress and health risks has been well documented, a better understanding between climate conditions and health risks is clearly needed.

Present technologies for human core body temperature and heat stress monitoring such as inserting a thermosensor in the esophagus, nasopharynx, rectum, or tympanum/auditory meatus are apparently neither clinically acceptable nor practicable for exploring thermoregulatory responses as a function of climate conditions. Recently, we therefore presented a new non-invasive method called Double Sensor located at the forehead, combining a skin surface temperature sensor with a heat flux sensor, to achieve this goal under various environmental conditions. Based on this experience the purpose of the present study was to explore the potential of the Double Sensor technology for monitoring core body temperature, heat stress and circadian rhythm in humans outside the laboratory during daily life. Specifically, the aim was to assess the feasibility of the approach to simultaneously monitor core body temperature (Double Sensor technology), heart rate (classical ECG as well as chest strap transmitter) and environmental conditions (ambient temperature, humidity, and atmospheric pressure) for 36 hours using a mobile monitoring system.

Data were collected using a portable physiological monitoring system (HealthLab, Koralewski Industrie-Elektronik, Hambühren) in 11 young, healthy subjects (4 woman and 7 men, aged 19 to 27) during a standardized activity protocol for 36 hours. The miniaturized system consists of a central processor for data storage and communication with a PC via Bluetooth (50 g, 46 x 85 x 16 mm) and two amplifiers (50 g, 46 x 85 x 16 mm), one for detecting the physiological data (heart rate via telemetry and heat flux via cable), and one for detecting the environmental conditions.

Initial results showed that heart rate data obtained by three-lead electrocardiography was prone to artifacts and poor subject discomfort. This approach was therefore replaced by a chest strap transmitter, allowing a wireless data recording and storage. This setup improved both data quality for heart rate as well as subject compliance. While all data sets confirmed the feasibility of the technique, it was also found that sudden changes of environmental conditions such as wind speed or large ambient temperature drops can substantially impact heat flux and therefore also jeopardize Double Sensor temperature recordings. Interestingly, however, Double Sensor temperature profiles reflected the circadian rhythm of the subjects very well. This confirms our previous findings in laboratory and clinical settings showing that in spite of deviations of up to about ± 1 °C compared to rectal temperature measurements the Double Sensor technology seems to be a valid, non-invasive approach for monitoring circadian rhythm.

It was concluded that future research is necessary to reduce the impact of varying environmental conditions outside the clinical and laboratory setting on Double Sensor temperature recordings. It is suggested that the full potential of the technique might be revealed by refining the external shielding and protection of the Double Sensor from environmental effects and eventually integrate the data into present telecommunication systems. This would promote the generation of human heat stress data in representative samples in diverse urban areas during different environmental conditions and provide the basis to link research on climate change and health to other research disciplines such as meteorology, informatics, architecture, and engineering. These collaborative efforts could be used to develop computer-models for predicting urban population- and region-specific human health risks of future extreme climate conditions, provide continuous support regarding preventive strategies for reducing climate-related morbidity and mortality, develop individual mobile health risk monitoring systems, and assist global and specific urban planning and architectural development.