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Wearable Sensor Technology to Predict Core Body Temperature: A Systematic Review

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INTRODUCTION:
Exertional heat-related illness (HRI) is increasing in incidence as global temperatures rise, with heat-related deaths increasing by 74% globally from 1980 to 2016[1]. Despite the frequency and potentially fatal consequences of undetected HRI, coaches, trainers, supervisors, and employers currently rely on visible cues and subjective assessments of their athletes and employees for early detection, such as malaise, confusion, thirst, ataxia, or excessive sweating. The measurement of core body temperature (CBT) using existing rectal, esophageal, or pill thermometers has been shown to predict HRI and its severity, but these measurement methods are excessively invasive, obstructive, or costly for high acuity and high motion settings. Noninvasive prediction of CBT using wearable technology and predictive algorithms offers the potential for continuous CBT monitoring and early intervention to prevent HRI in athletic, military, and intense work environments.

1. Fernandez, M. Extreme Heat-Caused Deaths Have Jumped 74% in the Last 30 Years Available online: https://www.axios.com/2021/08/20/extreme-heat-killed-nearly-400000-people-globally (accessed on 1 December 2022).

METHODS:
A systematic literature search was conducted in the Web of Science Core Collection database to identify works from 1 January 2000 until 31 December 2021 in which predicted CBT was compared to measured CBT in actively exercising subjects.

RESULTS:
This systematic review identified 20 studies representing a total of 25 distinct algorithms to predict core body temperature using wearable technology. The unweighted average RMSE after removal of an outlier was 0.28 ± 0.14 °C. Clinical validity standards of RMSE less than or equal to 0.5 °C were met by 17 out of 18 algorithms. However, few algorithms incorporated individual and environmental data into their core body temperature prediction algorithms, despite the known impact of individual health and situational and environmental factors on CBT, thus limiting the population and settings in which these algorithms can be considered valid. High accuracy across variable conditions and subjects was observed in the two algorithms in this review that reported the use of ML methods.

CONCLUSION:
Robust machine learning methods offer the ability to develop more accurate, reliable, and personalized CBT prediction algorithms using wearable devices through increased data processing abilities. The integration and interoperability of CBT prediction algorithms with existing HRI prevention and treatment tools, including heat indices such as the WBGT, athlete management systems, and electronic medical records, will further prevent HRI and increase the availability and speed of data access during critical heat events, improving the clinical decision-making process for athletic trainers and physicians, sports scientists, employers, and military officers.

Topic: Sports Medicine and Orthopedics

Presentation E-poster