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A SKIN-CONFORMAL CLOSED-LOOP WEARABLE FOR DUAL-DOMAIN BIOSENSING AND ADAPTIVE TRANSDERMAL THERAPEUTICS

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ABSTRACT

Wearable biomedical devices are rapidly transforming healthcare by enabling continuous, non invasive monitoring of physiological signals outside traditional clinical settings. This paper proposes a novel skin conformal, closed loop wearable system that integrates dual domain sensing, adaptive therapy, and intelligent inference. The device combines a microfluidic sweat collector with multi analyte electrochemical sensors to measure biomarkers such as glucose, lactate, cortisol, and electrolytes, alongside a flexible microelectrode grid that records autonomic nerve activity. These multimodal signals are fused in real time to generate a dynamic Homeostasis Score, providing a holistic assessment of physiological stability. When deviations are detected, a biodegradable microneedle patch delivers micro dosed transdermal interventions, ensuring timely and personalized therapeutic responses. The system's novelty lies in its dual domain sensing, closed loop therapeutic capability, and context aware scoring framework, which together redefine wearables from passive monitors into active health companions. Potential clinical applications include managing autonomic dysregulation, preventing exercise induced dehydration, and mitigating stress related glycemic variability. This work highlights the convergence of biosensing, neurophysiology, and adaptive therapeutics, paving the way for next generation wearable platforms in personalized medicine.

KEYWORDS: *Wearable Biosensors; Sweat Biomarkers; Microneedle Drug Delivery; Autonomic Monitoring; Closed Loop Therapeutics; Flexible Bioelectronics; TinyML Inference; Personalized Medicine; Homeostasis Score; Biomedical Engineering.*

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