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Functional assessment of wearable biosensors for physiological and nutritional monitoring in military operational contexts

Evaluarea funcțională a biosenzorilor purtabili pentru monitorizarea fiziologică și nutrițională în contexte operaționale militare

Wearable biosensors have emerged as essential technologies supporting the transition toward personalized and preventive health monitoring, particularly in environments characterized by intense physiological stress. In military operational settings, continuous monitoring of physiological and metabolic parameters is critical for preventing performance degradation, detecting early signs of fatigue, and reducing the risk of operational collapse. The aim of this study was to conduct a thematic and comparative evaluation of wearable biosensors used for physiological and nutritional monitoring in military and sport-analogous environments, identifying technological trends, functional limitations, and future development priorities. A systematic literature search was performed in the Web of Science Core Collection database covering the period 2015–2025. Twenty-six eligible studies were selected following predefined inclusion criteria. Data extraction included biosensor type, monitored physiological parameters, dominant transduction technology, application context, and study characteristics.

Seventeen distinct wearable biosensors were identified and classified according to monitored parameters and technological principles. Cardiovascular and respiratory indicators were the most frequently monitored variables, with heart rate assessed in 82% of devices, followed by heart rate variability, oxygen saturation, respiratory rate, and body temperature. Functional evaluation based on portability, accuracy, and practical utility scores revealed high operational adaptability, with an overall mean score of 13.36 out of 15. Multimodal biosensors represented 41% of analyzed devices, reflecting a growing trend toward integrated physiological monitoring systems.

Despite technological progress, the analysis highlighted persistent limitations related to multisensory integration, energy autonomy, and insufficient incorporation of nutritional biomarkers such as glucose or lactate. The findings emphasize the transition of wearable biosensors from experimental monitoring tools toward operational decision-support systems capable of enhancing physiological resilience in extreme environments.

The proposed functional framework contributes to the systematic evaluation and selection of wearable biosensors suitable for deployment in military contexts and supports future development of integrated, autonomous, and multiparametric monitoring technologies.

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