Accuracy and Cost Tradeoffs in Wearable Detection of Convulsive Seizures: A Comparative Study of Sensor Modalities

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Abstract

Objective: To systematically review and compare the diagnostic accuracy and relative cost of wearable multimodal detection systems for convulsive seizures.

Methods: A comprehensive search of PubMed/MEDLINE identified studies published between 2015 and 2025 reporting diagnostic accuracy of wearable seizure detection using accelerometer (ACC), gyroscope (Gyro), electrodermal activity (EDA), photoplethysmography (PPG), electrocardiography (ECG), or electromyography (EMG). Only free-full text, English-language articles with quantitative outcomes were included. Data extracted included sensitivity, false alarm rate (FAR) and sensor modalities. Risk of bias was assessed using QUADAS-2, with studies at high risk of bias (n = 4; one responder-only ECG study, three using cross-validation with internal threshold optimization) excluded from the final synthesis.

Results: Eleven studies met inclusion criteria; seven were retained after risk-of-bias assessment. Across retained studies, sensitivity for convulsive seizure detection was high (84.8–96.0%) with varying FARs (0.21–0.88 per 24 hours). Simpler accelerometer- and gyroscope-based devices performed as well as or better than more complex multimodal systems incorporating ECG, EMG, or EDA. Relative cost analysis grouped devices into three tiers: (1) low-cost ACC/Gyro, (2) mid-cost EDA/PPG, and (3) higher-cost ECG/EMG. On average, low-cost devices achieved comparable sensitivity with lower FARs than higher-cost modalities. Wearable detection of convulsive seizures shows remarkable accuracy across different sensor modalities, but cost and complexity do not necessarily enhance accuracy. Wrist-worn accelerometer-based systems offer a more practical and cost-effective solution for use in real-world settings, but additional prospective validation and improved standardized outcome reporting are required to establish a stronger evidence base.