

MIGRAINE MONITORING AND ATTACK PREDICTION IN THE PREICTAL PHASE USING MACHINE LEARNING APPROACHES COMBINING E-DIARIES AND BIOLOGICAL VARIABLES COLLECTED THROUGH WEARABLE SENSORS: THE MIGRAMETER STUDY

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Background. Migraine is a disabling disorder characterized by recurrent and unpredictable attacks. Physiological and behavioral changes may occur hours before headache onset, even without prodromal symptoms, reflecting changes of the central and autonomic nervous system. We aimed to develop a machine learning model integrating e-diary and high-resolution wearable sensor data to identify early warning signs of the pre-ictal phase with the potential to support timely and personalized interventions and ultimately improve the quality of life of individuals with migraine.

Methods. Adults with episodic or chronic migraine underwent prospective monitoring for ≥28 days using a wearable device continuously recording pulse rate, electrodermal activity, skin temperature, actigraphy and sleep parameters, together with an e-diary (MigraMeter). Sensors data were processed into 10-minute segments and labelled according to migraine phases, as preictal, ictal, postictal and interictal, according to temporal proximity on migraine onset time, to enable a time-resolved characterization of interindividual changes. Machine learning models were trained and validated using 10-fold cross-validation. The primary outcome was the performance of the model to discriminate the interictal-pre-ictal phase transition within different time windows (6–48 hours).

Results. Nineteen participants (median age 41 years [IQR 30–45], 84.2% female, 73.7% with episodic migraine). were monitored for a median period of 39 days (IQR 22–49), with a median of 5 monthly migraine days (IQR 3–9). In the 12 hours window, CatBoost combined with Select K-Best feature selection achieved the best performance (AUC-ROC 0.88±0.10; balanced accuracy 0.71), demonstrating robust identification of physiological alterations preceding attacks. Electrodermal activity was the most informative feature, followed by pulse rate and skin temperature. The model consistently achieved AUC values >0.70 across individuals indicating robust discriminative ability in the preictal windows (6-48 hours). In contrast, F1-scores were more variable, suggesting differences in precision–recall balance related to individual physiological patterns and class distribution.

Conclusions. The CatBoost model showed the highest discriminative ability and robustness up to the 48 hours pre-ictal window, demonstrating good performance in detecting the interictal-to-pre-ictal transition, largely driven by autonomic physiological features. These findings support the feasibility of developing machine learning–based tools for the early prediction of migraine attacks through individualized risk estimation using continuous physiological data.