Corti-call: A Watch To Answer All Calls For Addison's Disease and Cortisol Health

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Abstract

Autoimmune Adrenalitis, or Addison's disease, is a rare endocrine disorder resulting from a destroyed bilateral adrenal cortex, lowering cortisol levels in the body (Munir et al., 2024). Symptoms include salt cravings, fainting, fatigue, and hypoglycemia (Addison's disease, 2024). Patient cortisol levels are often tracked using electro-chemiluminescence or radio-immunoassay, requiring complicated instruments and analysis, making it ineffective for daily tracking (Kim et al., 2025). Patients with unnecessarily high doses of corticosteroids risk osteoporosis and insomnia, while forgetting to take doses can deteriorate well-being and cause adrenal crisis (NHS choices 2021). This study proposes a biosensor watch that assesses individual cortisol levels, combined with an app that monitors health trends, risks, medication times, and ways to prevent worsening conditions. The watch uses a gold nanoparticle (AuNP) functionalized laser-induced graphene interdigitated electrode (LIG-IDE) and electrochemical impedance spectroscopy (EIS) to detect cortisol from a range of 0.1pm to 100nm in synthetic human sweat (Duke et al., 2025). It has a high specificity against similar molecules and can detect cortisol levels within 3 minutes (Hannibal KE et al., 2014). The watch syncs data through the app Corti-Call, which forecasts trends in data and records health history. It provides notifications and reminders to administer medication, along with personalized dietary recommendations for foods that can mediate cortisol levels using the latent-factor-based model(LUFM) for user-food-meal recommendations (Nguyen et al., 2024). Furthermore, it uses the RL-PPO algorithm for drug scheduling. Future applications involve using saliva and swabs inserted into the watch for individuals with lower perspiration levels.

Key Words: Cortisol, Robotics, AI algorithm, Dieting, Drug administration

1. Introduction

Addison's disease is a rare, irreversible adrenal insufficiency affecting about 1 in 100,000 people (Mayo Clinic, 2024). Symptoms appear only after 90% of the adrenal cortex is damaged, making early diagnosis difficult. Current cortisol tests lack portability and real-time tracking. A wearable sweat-monitoring watch offers a noninvasive, continuous solution. Using gold nanoparticles on laser-induced graphene electrodes (LIG-IDE), sensors can flexibly and accurately detect cortisol via immobilized antibodies, providing an inexpensive, disposable, and sustainable alternative (Gao, F., et al., 2023).

2. Cortisol Detection Method

An effective sweat sensor must isolate irritants and allow real-time cortisol monitoring(Gao, F., et al., 2023). A promising biosensor using gold nanoparticle (AuNP) laser-induced graphene interdigitated electrodes (LIG-IDE) enables label-free, non-faradaic, capacitive cortisol detection—ideal for wearable use due to its low cost and point-of-care potential (Duke et al., 2025). As shown in Figure 1, AuNPs are deposited onto LIG, followed by a 3-mercaptopropionic acid (3-MPA) monolayer. EDC/NHS chemistry activates carboxyl groups to immobilize anti-cortisol antibodies. BSA blocks non-specific binding, and detection occurs in a PBS solution with $K_4[Fe(CN)_6]/K_3[Fe(CN)_6]$ as the electrolyte (Duke et al., 2025).

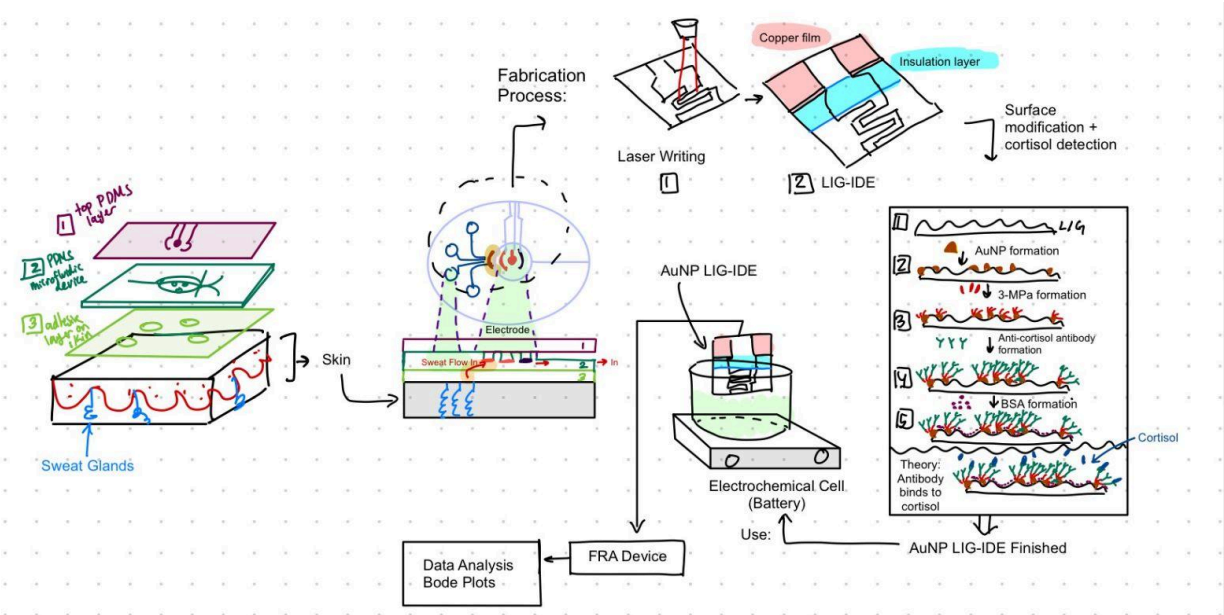

Figure 1- Structure of the bottom of the watch apparatus, along with electrodes, formation of the AuNG LIG-IDE, and how it will transmit information across the watch.

The biosensor shows excellent repeatability with a maximum %RSD of 0.41% at 1 pm, demonstrating outstanding analytical performance compared to recent studies (Duke et al., 2025). This makes it well-suited for skin-to-watch cortisol monitoring.

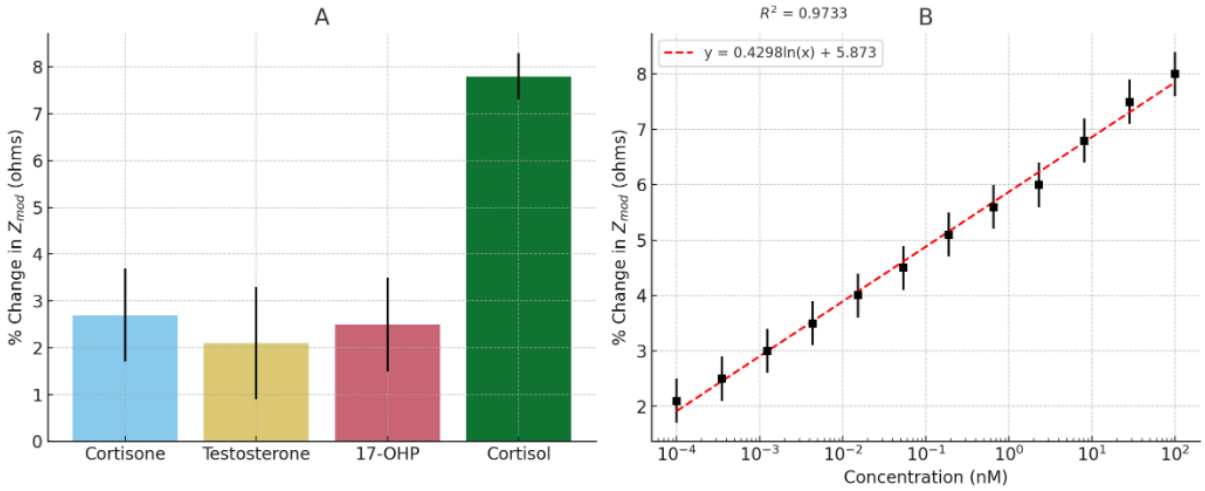

Figure 2- A) Specificity against similarly structured hormones (n=9). B) Linear calibration curve for detection of different cortisol concentrations from 0.1pm to 100nm in synthetic sweat with error bars showing standard deviations for the measured Z_{mod} values.

Using electrochemical spectroscopy (EIS) within the FRA, the analyzing time would only be 3 minutes for cortisol levels, which is faster than the rate of rise of cortisol levels in most patients after high-stress events, being 15 minutes, meaning this could be a feasible reaction time (Hannibal KE et al., 2014).

3. Watch Hardware and Sweat Detection Integration

Most of the hardware of the watch is based on a standard Apple Watch, as shown in Figure 3 (*Expanded view of Apple Watch | Download Scientific Diagram*). There is an addition of the apparatus for cortisol detection in sweat, which includes the AuNP LIG-IDE, an electrochemical cell, and a frequency resonance analyzer (FRA), which could be an AD5933, to analyze the responses in the electrochemical cell (*Ad5933.pdf*).

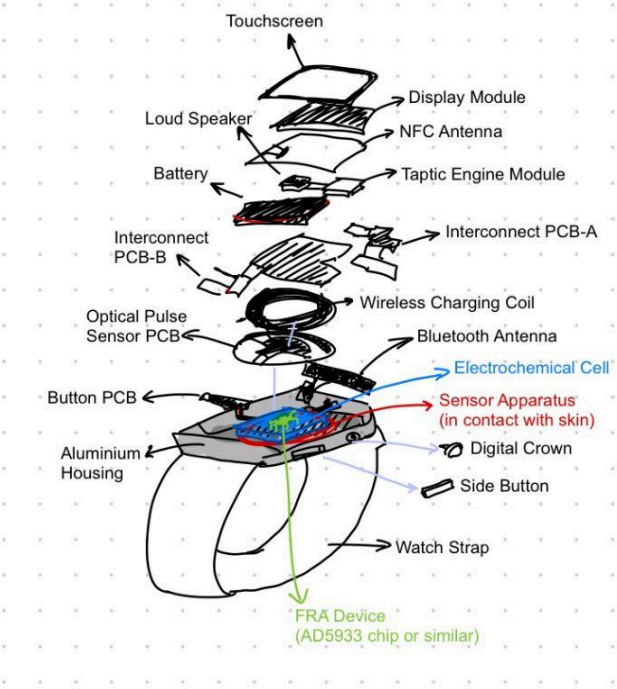

Figure 3 - Exploded view of the watch with all inside components, along with electrodes and other apparatus included in Figure 1.

4. App and Watch Integration

Cortisol levels detected by the watch are stored in a HealthKit-like system and synced to the Corti-Call app. Using the LUFM algorithm, Corti-Call analyzes past data to recommend meals, displaying food images and recipe links via OpenAI API. Based on the RL-PPO algorithm, it also suggests corticosteroid dosage times with reminders. The app includes an emergency cortisol card with life-saving info, a QR code, and a 911 button. UI designs are shown in Figures 4 and 5.

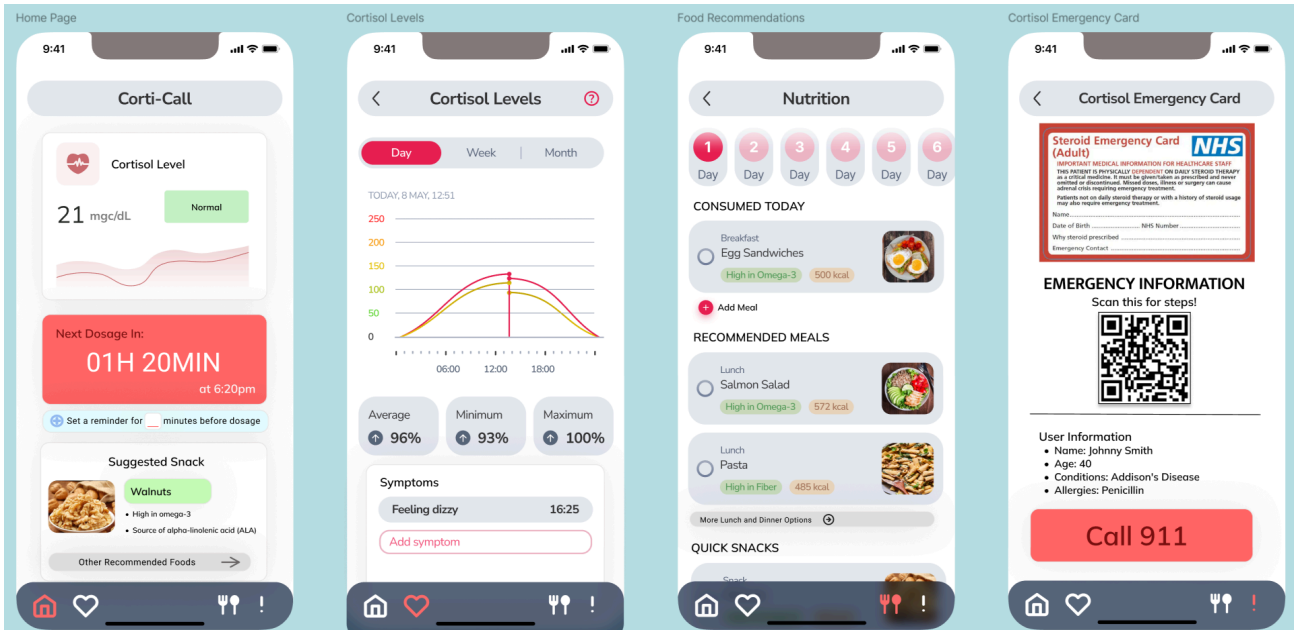

Figure 4 - A Prototype of the App Corti-Call, including (from far left to far right) the home page, history of the cortisol levels and symptoms, nutritional advice and food diaries, and the cortisol emergency card.

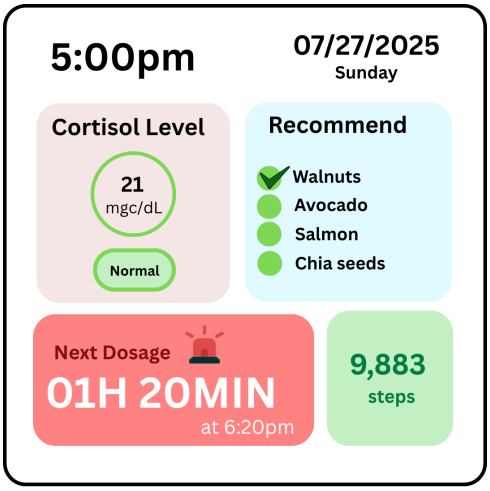

Figure 5 - The display screen of the Corti-Call watch, which presents a reminder about the next dosage time and dietary goals to ensure proper nutrition.

5. Algorithms Used

5.1 Food Recommendation System

The latent-factor-based model (LUFM) for User-Food-Meal Recommendation, introduced by the Vietnam National University, recommends products based on products they can or prefer to eat (Nhung et al., 2024). Tested on the MyFitnessPal dataset, LUFM outperforms Neighbour-Based models (NUFM) by capturing more latent patterns, achieving a higher F1 score of about 0.4 compared to NUFM and PPMI, as shown in Figure 6.

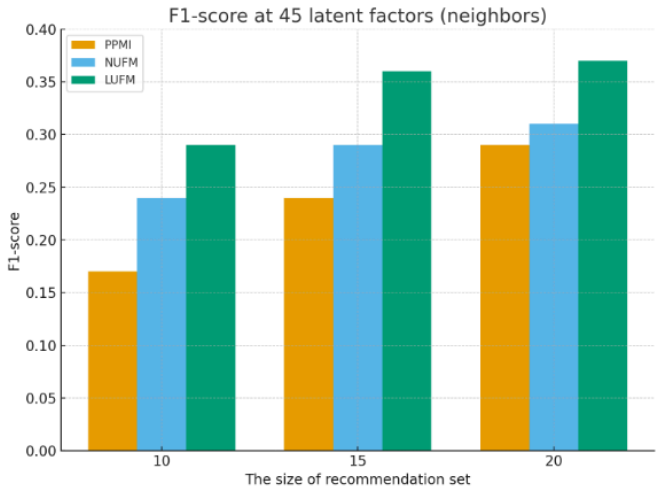

Figure 6 - An adapted graph from the 'Approaches for Extending Recommendation Model for Food Choices in Meals' showing the accuracy of each model, where LUFM surpasses the F1 accuracy.

The food recommendation model can be used for individuals who have lots of food preferences and need a more accurate, personalized recommendation. This can be integrated within our app to provide notifications of specific, more nutritious foods the individual can eat to resolve their cravings and maintain their cortisol levels.

5.2 Cortisol Administration Algorithms

The RL-PPO algorithm by Gorrepati and Potla models patient-treatment interactions as a POMDP to capture temporal dependencies and uncertainty in medical decisions (Gorrepati L. & Potla RT, 2025). It maintained accuracy with less than 2% degradation and consistent reward convergence in simulations with up to 200,000 patients (Figure 7).

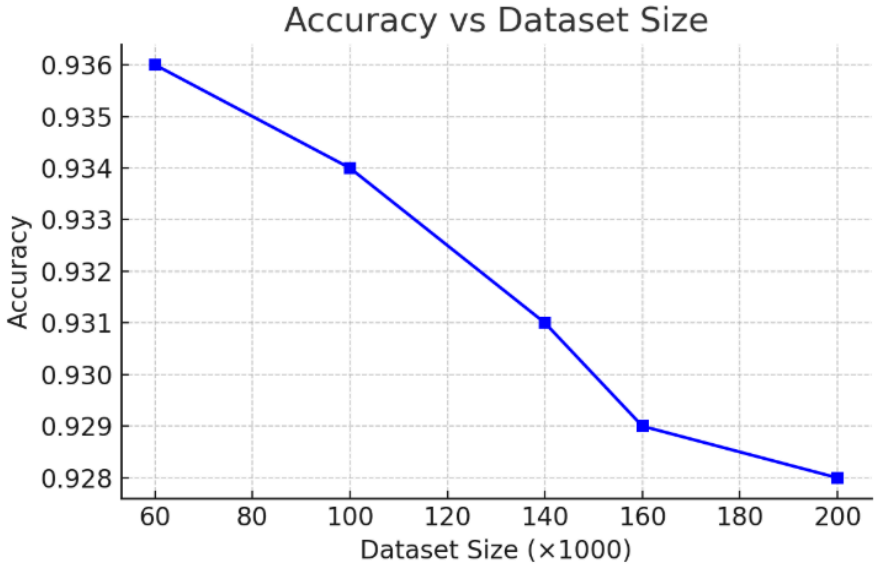

Figure 7 - Accuracy of RL-PPO against dataset size, showing there is only a maximum of 2% decrease in accuracy even up to a dataset size of 200,000.

The system achieved 93.6% accuracy, 0.937 F1-score, and 0.964 ROC-AUC on 500,000 samples from the Amsterdam Medical Data Science dataset (UMC, *Amsterdam Medical Data Science*). Physician review showed 92% clinical alignment and 94.6% explainability, demonstrating trustworthiness. Integrating this algorithm into our watch offers doctor-approved dosage recommendations, helping reduce fatigue and autoimmune complications from medication misuse.

6. Discussions

Corti-Call effectively monitors cortisol in Addison's patients with its portable, point-of-care design and machine-learning interface. It balances nutritional and hormonal needs through advanced algorithms for food and medication management. The system can be adapted for other cortisol-related conditions like Cushing's syndrome. For rapid cortisol changes under 3 minutes, faster methods than EIS may be needed, requiring device modifications.

7. References

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