2nd PANHELLENIC CONGRESS OF MEDICAL PHYSICS
4-6 OCTOBER 2024| EUGENIDES FOUNDATION

An impedimetric cell-based biosensor for Prostate-Specific Antigen (PSA) Detection

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1. Background-Aim

- Prostate cancer (PCa) is the second most frequent type of malignancy cancer among men worldwide, and the most common cancer in men in 112 countries, accounting for 15% of cancers. Projections suggesting that the number of new cases annually will rise from 1·4 million in 2020 to 2·9 million by 2040.

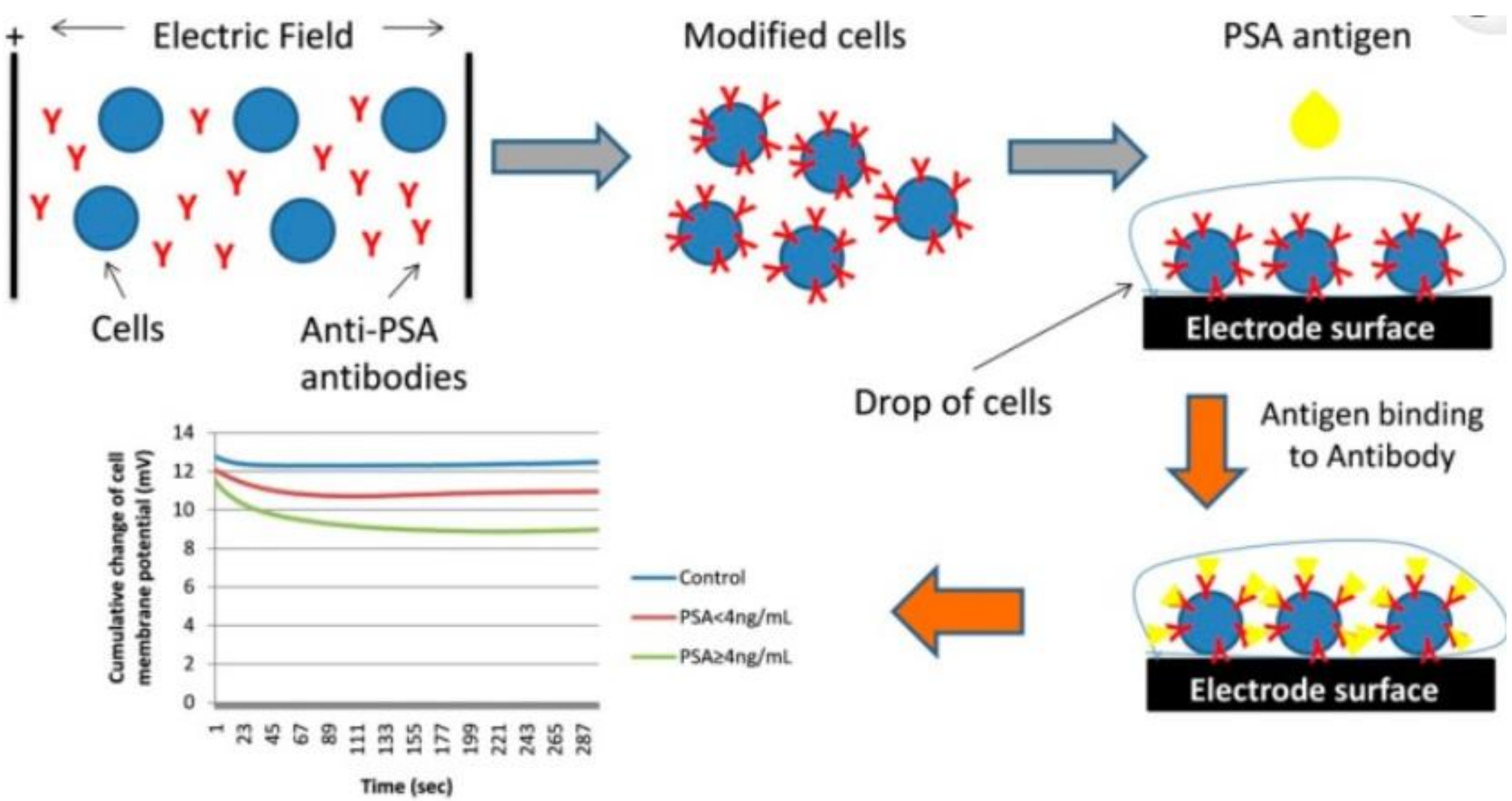
- Early detection, mainly through prostate-specific antigen (PSA) blood tests, has improved diagnostic rates. Prostate-specific antigen (PSA), encoded by the KLK3 gene, is an enzyme from the prostate that degrades seminal proteins, with elevated levels released into circulation when prostate tissue is disrupted by tumors. Prostate cancer mortality has declined by 53% since the peak in 1993 because of earlier detection through widespread screening with the PSA test and advances in treatment.

- Although PSA testing reduces deaths from prostate cancer, between 20% and 60% of cancers detected using PSA testing are estimated to be overdiagnoses. PSA testing's reliability is debated, especially for levels in the “gray zone” (4–10 ng/mL). Recent efforts focus on increasing PSA testing frequency to assess PSA velocity for better risk stratification, with emerging biosensor technologies enhancing detection speed, cost-efficiency, and accuracy.

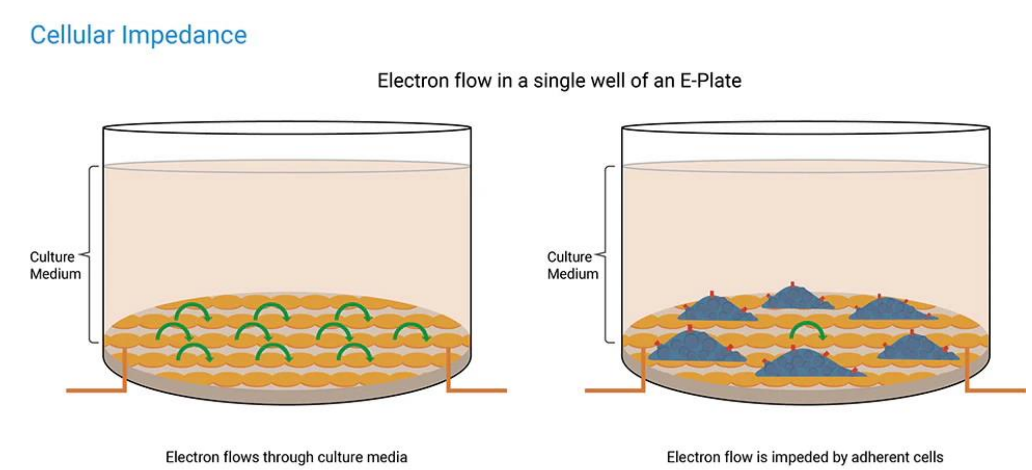
1. Background-Aim

In recent years, numerous electrochemical biosensing approaches have been developed, utilizing a variety of biorecognition elements for the detection of PSA in both standard solutions and biological samples. Electrochemical detection offers several advantages as an analytical method, including rapid testing, relatively low cost, and, in many cases, portability, making it a promising tool for point-of-care diagnostics.

We have developed an innovative point-of-care system for PSA detection in human serum using molecular identification through membrane engineering (MIME) and the bioelectric recognition assay (BERA). This combined approach detects changes in engineered cell membrane potential upon interaction with the target antigen, enabling ultra-rapid (3–5 min) and highly sensitive detection.

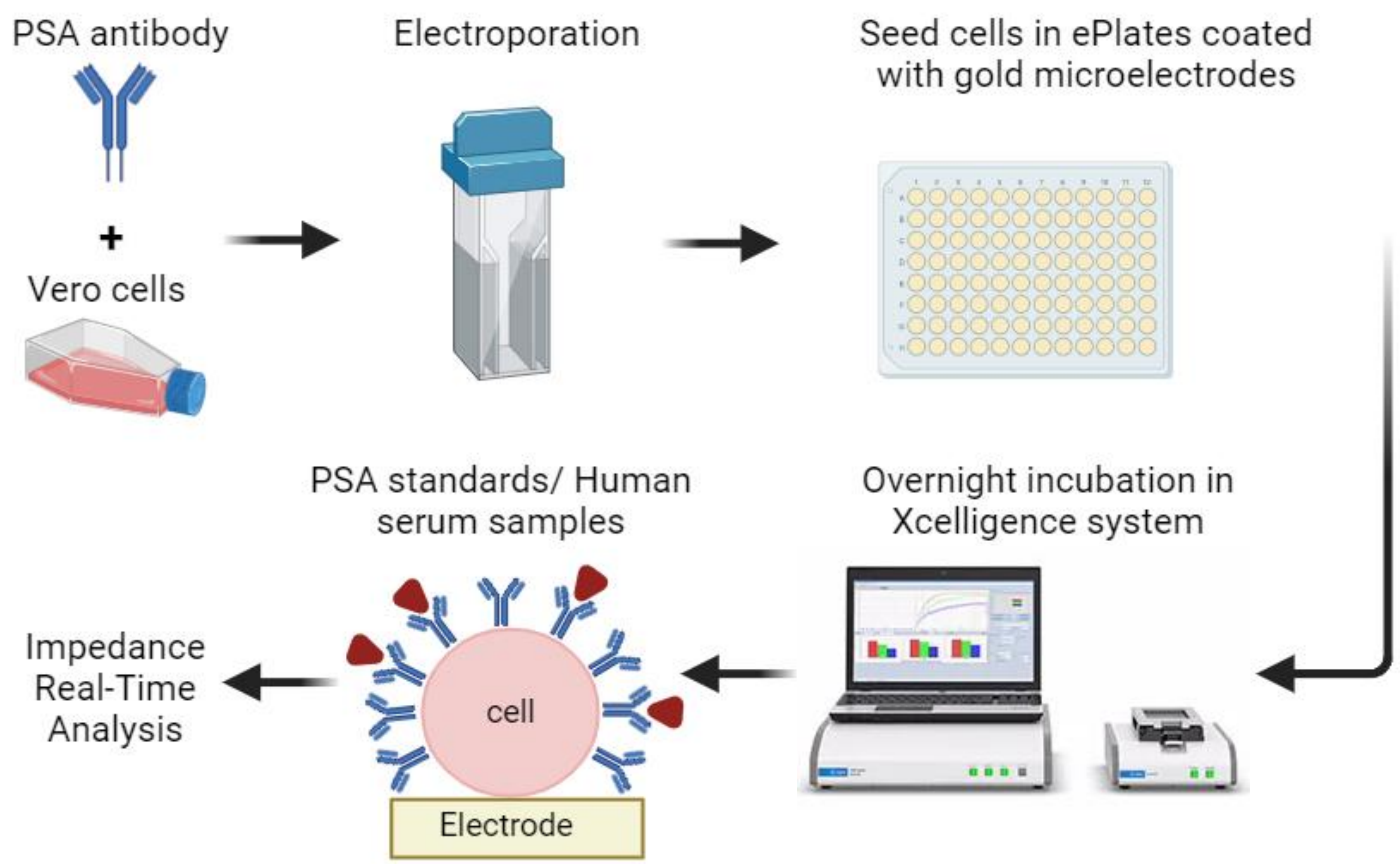


We have advanced our technology by developing a highly sensitive real-time PSA sensor, utilizing xCELLigence Real-Time Cell Analysis for enhanced precision and performance.



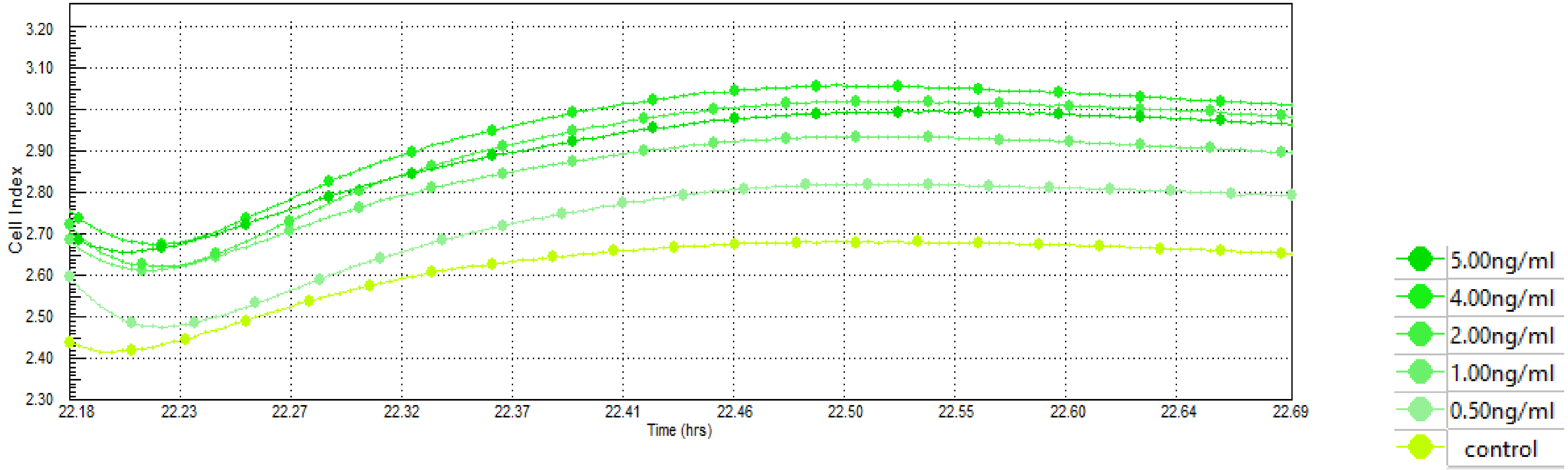
2. Materials & Methods

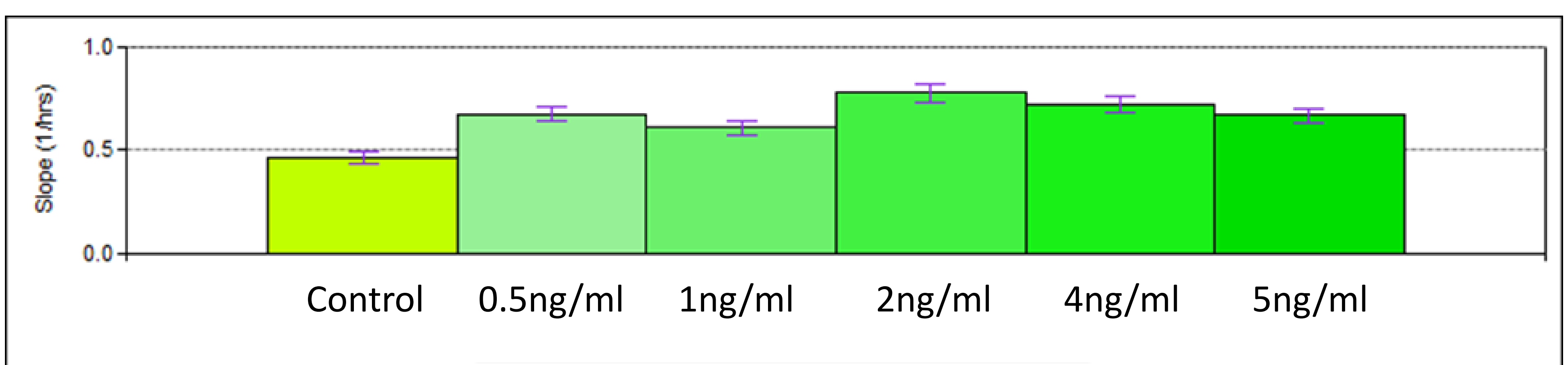
xCELLigence Real-Time Cell Analysis offers a simple yet powerful tool for live cell analysis, enabling continuous, label-free monitoring of cell health, behavior, and function through impedance and imaging assays. This non-invasive biosensor technology provides quantitative insights into cell number, proliferation, attachment quality delivering sensitive and real-time results.



3. Results

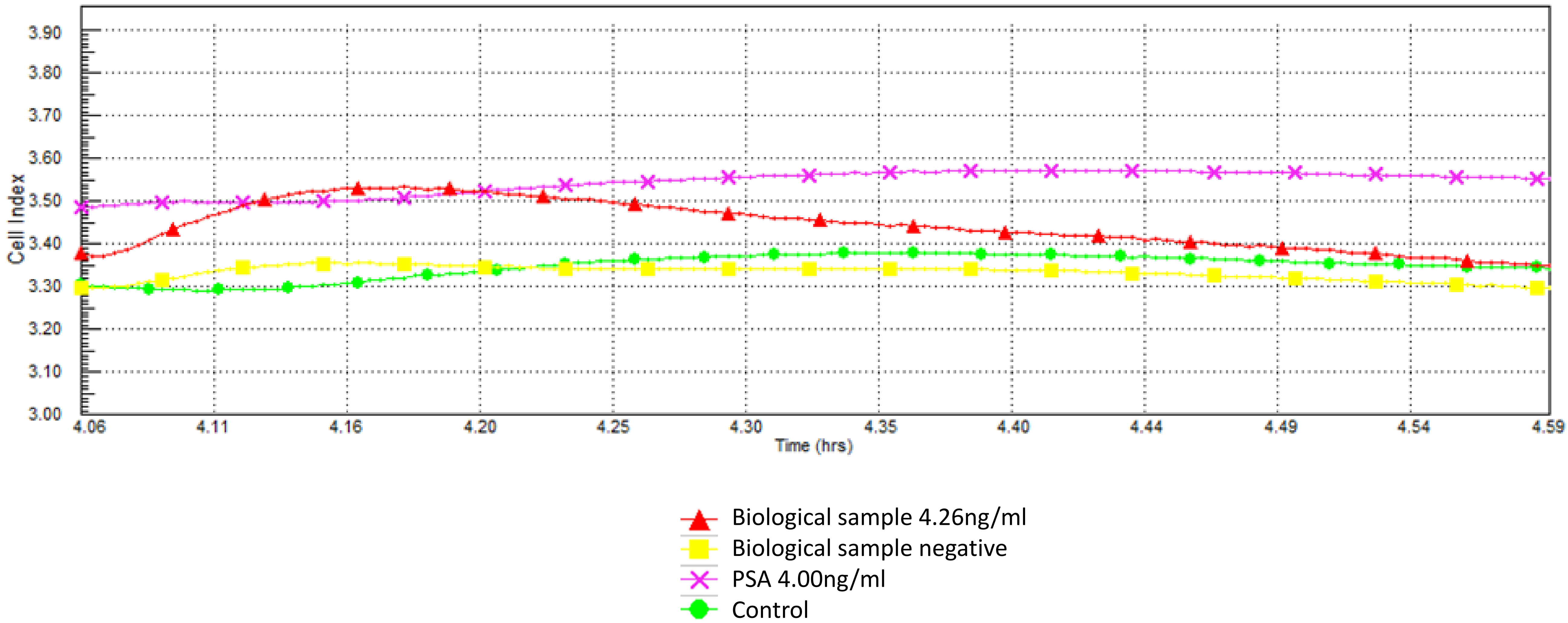
Changes in electrical impedance are represented by a unitless parameter called the 'Cell Index (CI).' In the absence of cells, the electrode impedance and CI are zero. The binding of PSA to the surface-bound PSA antibody induces changes in CI. The tested PSA concentrations (0.5–5 ng/mL) exhibited dose-dependent variations in CI, resulting in a well-defined and distinct standard curve.





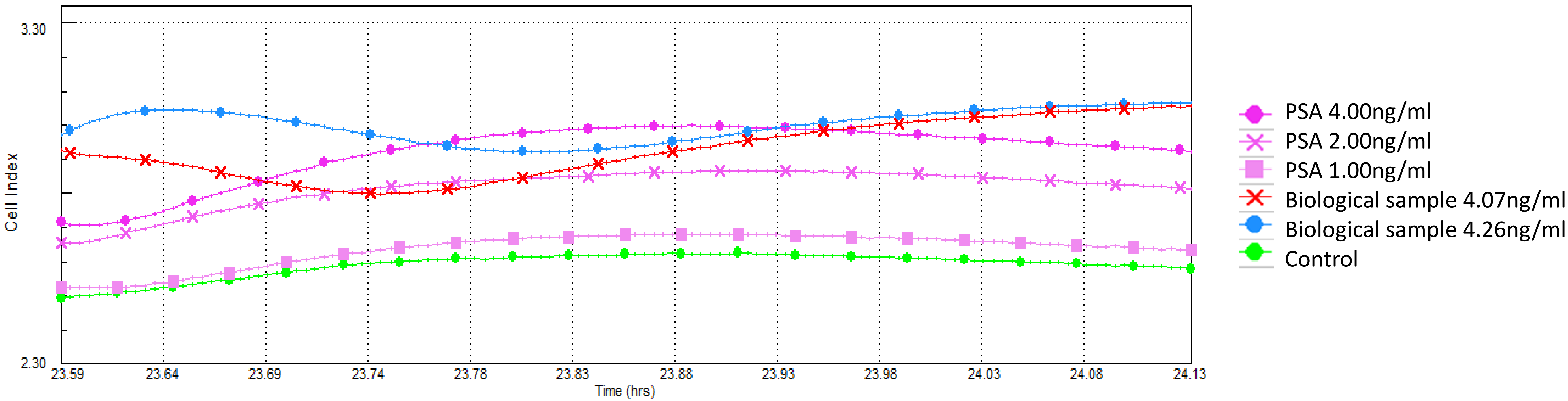
3. Results

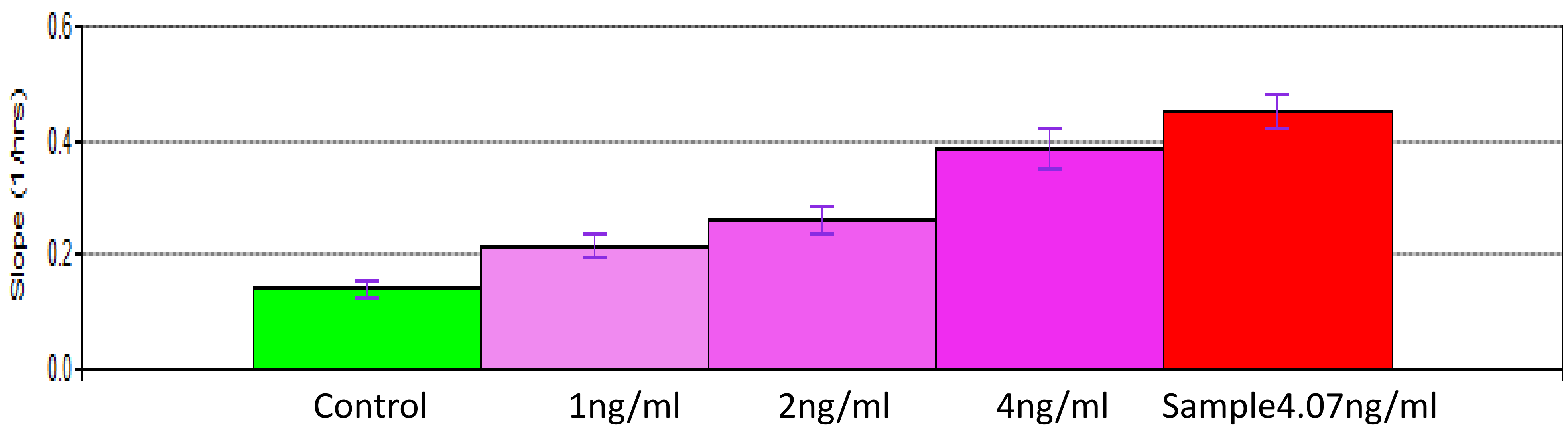
Human serum samples were utilized to validate the Xcelligence biosensor system for PSA detection. PSA levels in these samples had been previously quantified using a standard immunoassay technique. The validation included serum samples with varying PSA concentrations, including both PSA-negative and PSA-positive samples.



3. Results

The Cell Index response to biological samples with known PSA concentrations was accurately measured using the xCELLigence system.





4. Conclusions

- ❖ Prostate cancer is often detected through elevated levels of prostate-specific antigen (PSA) in the blood, with PSA testing serving as a key screening tool for early diagnosis and monitoring of the disease.
- ❖ Xcelligence technology is applicable for impedance measurements in sensor applications. It employs real-time, label-free cell analysis by measuring electrical impedance across sensor electrodes.
- ❖ Molecular identification through membrane engineering (MIME) and bioelectric recognition assay (BERA) technology, integrated with the Xcelligence system, has been utilized to develop an innovative biosensor for the detection of PSA in human serum.
- ❖ This biosensing system exhibited great responsiveness to varying PSA concentrations, generating a well-defined standard curve.
- ❖ Real-time biosensor responses to human serum samples with known PSA concentrations further validated the accuracy of this innovative system.

5. References

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