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Article

Intelligent application of biosensor system in university sports health monitoring

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Abstract: The study seeks to examine the design, development, and assessment of an intelligent biosensor system for tracking the health status of university athletes with specific reference to motion, temperature, and blood pressure. The system incorporates state-of-the-art sensor technologies and data analytics for non-contact, continuous tracking of physiological signs during exercise. A series of tests under resting, moderate, and high activity levels provided high accuracy values with MAE below 5 mmHg for blood pressure and 0.3 °C for temperature. The motion data showed a significant correlation with the reference systems, indicating that the system was accurate in dynamic conditions. The findings show that the biosensor system can help manage sports health by detecting overexertion, illness, and stress early to protect the athletes and improve their performance.

Keywords: biosensor system; overexertion detection; non-invasive health monitoring; sports health monitoring; real-time physiological monitoring; motion tracking

1. Introduction

Universities play a very important role in the all-round development of a student. In terms of academics and sports. People must engage in physical activities through sports, as they help enhance the physical fitness, mental health, and overall well-being of the human body. However, the high strenuous activities and increased competition in sports at the university level have been of concern due to adverse effects such as injuries, overworking, and stress-related complications. Current approaches to tracking sports health involve brief checks at set times, which do not give the same information about a person's status at any given moment. There is a need for new health monitoring systems. Which can provide timely information to facilitate timely interventions. An intelligent sports health monitoring system helps to improve student performance and management. This implies that there is a need to engage in the application of technologies like biosensors. This is to enhance the tracking and management of sports health indicators in universities [1].

Biosensors are a revolutionary tool in health monitoring. This is because they provide high accuracy and real-time information. These devices which incorporate biological sensors with enhanced signal processing systems are capable of assessing various important health conditions. Like heart rate, blood pressure, temperature, and body movement. Thus, in the case of sports health monitoring, biosensors allow for the constant assessment of different parameters. Such indicates an individual's state of health, well-being, and fitness. They are well suited for use within universities where a range of sports are practiced. And where there is a need for versatile tracking systems. Also, biosensors help in identifying the initial signs of overtraining, dehydration, or any other health complications. Advancements in technology lead to a reduction in the size and integration of biosensors with other systems. And data analysis. Hence, creating a complete system for sports health management [2]. Recent advancements in biosensor applications have significantly improved real-time health tracking. For example, Smith et al. [2] highlighted the integration of wearable biosensors in reshaping healthcare [2]. Reshaping healthcare with wearable biosensors. Additionally, Xu et al. [3] provided insights into wireless biosensor technologies for real-time health monitoring [3]. Technologies and applications in wireless biosensors for real-time health monitoring. These studies emphasize the evolving capabilities of biosensors in detecting physiological parameters with higher accuracy.

Objectives and scope of the study

The purpose of this research work is to develop and assess an intelligent biosensor-based system. This will be for use in university sports health monitoring. The goals include creating a modular biosensor system for motion. A blood pressure and temperature monitoring system. And performing experiments in different conditions. Also, analyzing the results to determine the system's efficiency. With these goals in mind, the research aims to help develop and improve preventative, evidence-based approaches to sports health management.

2. Method design of intelligent application of biosensor system in sports health monitoring

2.1. Design of motion biosensor system module

The motion biosensor system module is designed to capture, process, and analyze real-time data. Only data that is related to an individual's physical movements during sports activities (see **Figure 1**). The module comprises three primary components. Motion detection sensors, data processing units, and communication interfaces [3]. Sensors typically include accelerometers, gyroscopes, and magnetometers. These collectively form an inertial measurement unit (IMU). These devices measure linear acceleration, angular velocity, and orientation changes, respectively. They provide comprehensive motion data.

- The accelerometer measures the acceleration of body movement along the x, y, and z axes. The acceleration (a) is computed as;

$$a = \sqrt{a_x^2 + a_y^2 + a_z^2} \tag{1}$$

- The gyroscope calculates the angular velocity (ω) about each axis. Angular displacement (θ) can be derived by integrating angular velocity over time;

$$\theta = \int \omega dt \tag{2}$$

- The magnetometer measures magnetic field strength to determine orientation. Combining data from the magnetometer and gyroscope using a complementary filter or Kalman filter enhances accuracy in motion tracking;

$$\hat{x}_t = x_t + K(z_t - x_t) \quad (3)$$

The motion biosensor module includes a microcontroller. This is to process sensor data. Also, a wireless transmitter (e.g., Bluetooth Low Energy). This is to send the information to a central monitoring system [4]. Integration of the motion biosensor module into university sports involves three critical stages. Sensor deployment, activity-specific calibration, and real-time monitoring and feedback. **Figure 1** below is a system architecture diagram illustrating sensor integration, data processing, and wireless transmission for real-time biosensor monitoring.

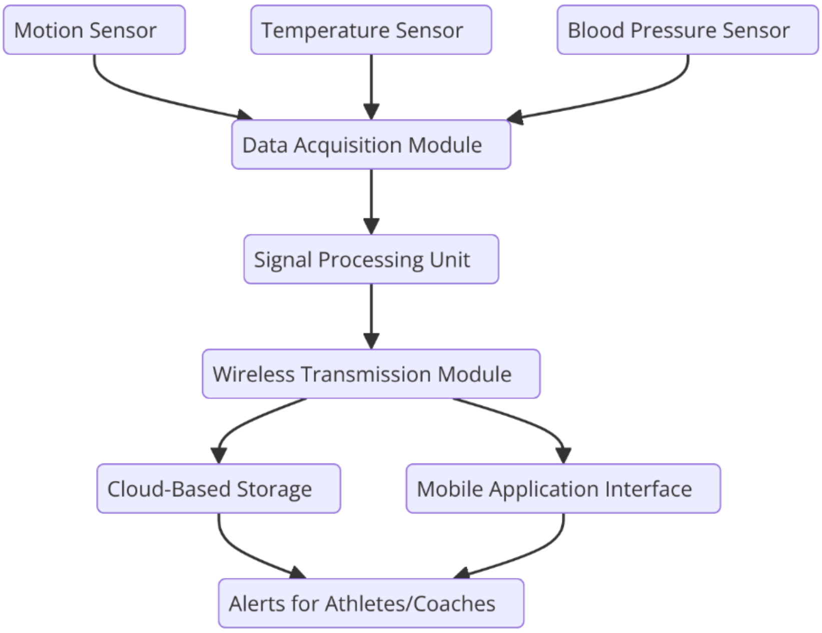

Figure 1. System architecture diagram.

- The motion sensors are embedded in wearable devices such as smart bands, insoles, or clothing. These placements ensure minimal interference with the athlete's natural movements while maximizing data accuracy [4,5].
- Different sports activities, such as running, swimming, or basketball, exhibit unique movement patterns. Calibration involves collecting baseline data for each activity and fine-tuning the motion sensors accordingly. For example, in running, stride length (SL) and stride frequency (SF) are crucial parameters;

$$V = SL \times SF \quad (4)$$

- During sports activities, the motion biosensor system captures dynamic data to evaluate performance, fatigue, and potential injury risks. For instance, excessive lateral acceleration (aL) during pivoting movements in basketball might indicate instability, increasing the risk of ankle sprains;

$$a_L = \sqrt{a_y^2 + a_z^2} \quad (5)$$

To ensure the robustness and reliability of the motion biosensor module, several design considerations are implemented:

- Efficient energy management extends battery life, making the system suitable for prolonged usage during sports events.
- Filters, such as low-pass filters, are applied to raw sensor data to minimize noise and enhance signal quality;

$$Y(n) = (1 - \alpha)Y(n - 1) + \alpha X(n) \quad (6)$$

- Combining data from multiple sensors provides a more accurate representation of motion. The Madgwick filter or extended Kalman filter can be employed for sensor fusion.

The motion biosensor module is tested for sprint performance monitoring in a university sports team [5]. Metrics like acceleration, deceleration, and cadence are analyzed. To provide actionable insights. The module computes the rate of change of velocity (ar) to evaluate sprinting efficiency;

$$a_r = \frac{dv}{dt} \quad (7)$$

Additionally, asymmetry in limb movement, detected through differential acceleration (Δa) between the left and right limbs, is flagged as a potential performance imbalance;

$$\Delta a = |a_{left} - a_{right}| \quad (8)$$

2.2. Design of blood pressure biosensor system module

2.2.1. Framework for continuous blood pressure monitoring

CBPM is one of the main subsystems of the biosensor system that is developed for university sports health management [6]. The system uses a non-contact approach and gives the immediate values of systolic (BPsystolic) and diastolic (BPdiastolic) blood pressure. These parameters are critical in establishing cardiovascular fitness and identifying changes that may occur as a result of stress during workouts. The module is a hybrid of optical, pressure, and machine learning methods. The primary means for continuous monitoring is photoplethysmography (PPG) which is based on light absorption changes within microvascular tissues due to blood volume variations [6]. PTT is the time taken for the arterial pulse wave to travel between two arterial sites while the PPG waveform is recorded. Thus, the correlation between blood pressure and PTT could be expressed as;

$$BP = BP_{base} - k \times PTT \quad (9)$$

Pulse transit time has an inverse relationship with arterial stiffness that is directly affected by blood pressure. PTT is computed using the time delay (Δt) between the occurrence of the R-peak of the ECG signal and the PPG peak;

$$PTT = t_{PPG} - t_{ECG} \quad (10)$$

The biosensor system incorporates ECG electrodes and PPG sensors into wearable gadgets like wristbands or chest belts (see **Figures 2** and **3**). It is also equipped with a microcontroller for data processing and also has wireless modules for transmitting the data to a central monitoring system. Sophisticated signal processing methods are applied to reduce the noise and errors caused by movement and provide reliable measurements in real-world situations [6,7].

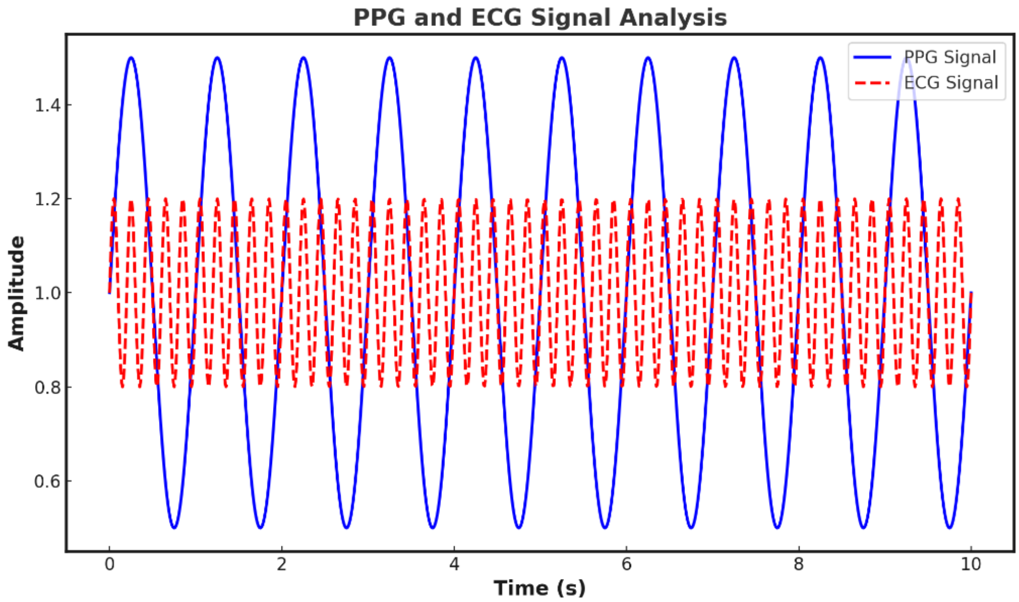

Figure 2. PPG and ECG signal analysis.

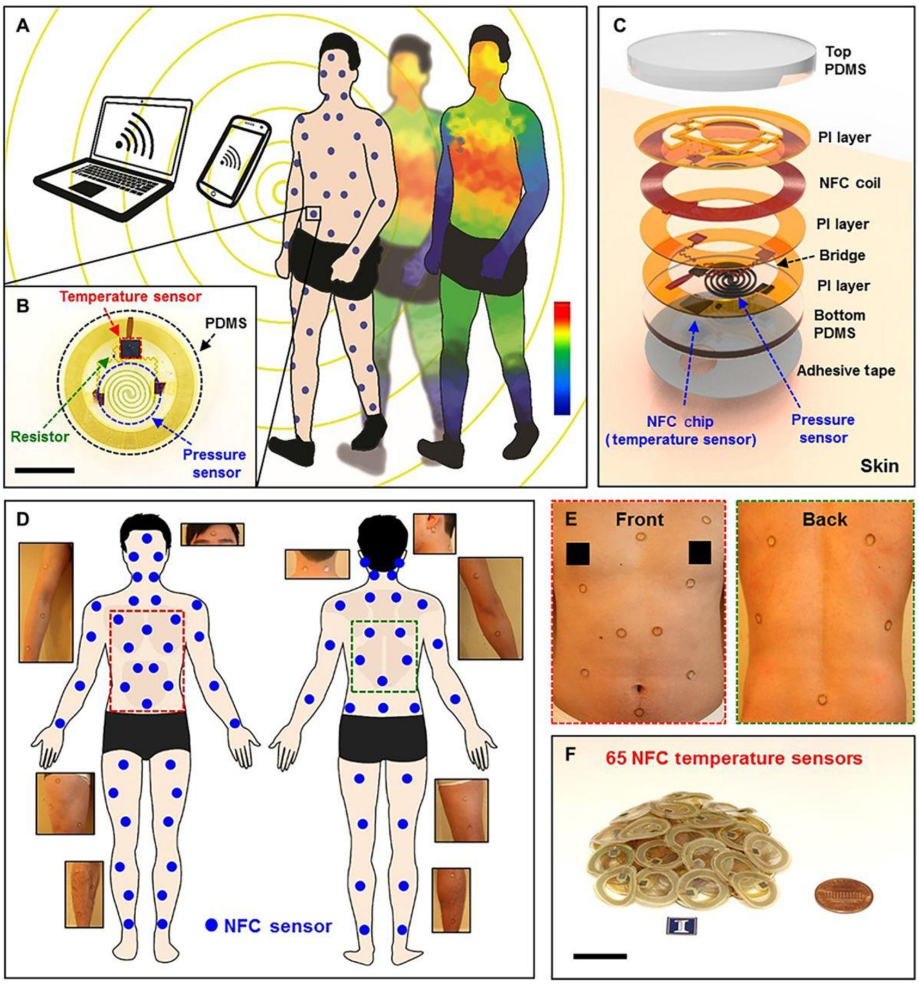

Figure 3. Sensor placements on the human body (e.g., wrist, chest, ankle) for motion, temperature, and blood pressure monitoring.

The system also includes some adaptive strategies to compensate for the variations in the vascular structures. Calibration requires the initial measurements to be made using a conventional cuff-based device, whereby the subsequent personalized k-value is derived from the PTT-BP relationship.

2.2.2. Relevance to stress and cardiovascular health in sports

Blood pressure is a significant marker of stress and cardiovascular health, especially in the stressful environment of university sports. In physical activity, the cardiovascular system experiences various alterations in an attempt to supply the muscle tissues with more oxygen and nutrients. These changes include an increase in heart rate, an increase in cardiac output, and vasodilation in the skeletal muscle arteries [7,8]. The biosensor module identifies these changes in blood pressure to provide a comprehensive understanding of the cardiovascular system of an athlete. For example, the mean arterial pressure (MAP) is an important variable that represents the average arterial pressure during a cardiac cycle. It is calculated as;

$$MAP = \frac{1}{3}BP_{systolic} + \frac{2}{3}BP_{diastotic} \tag{11}$$

Monitoring MAP can be used in determining adequate blood flow to the various organs of the body, especially during periods of physical activity. Stress-related cardiovascular effects, including increased blood pressure, are also closely monitored. Psychological stress may increase the level of physiological load, and therefore the cardiovascular burden. The biosensor system identifies stress-induced hypertension by measuring changes in blood pressure from normal levels. Machine learning algorithms that use historical data as input can improve the detection of stress-related changes by identifying the difference between regular exercise stress and stress due to other causes [8]. One important use of this feature is in the prevention of OTS, a state that is defined by chronic fatigue, increased resting heart rate, and high blood pressure resulting from excessive training. Through real-time tracking of blood pressure patterns, the system raises alarms of early OTS, thus allowing for timely action.

The blood pressure biosensor module has been coupled with data analytics to give feedback to athletes and coaches. The information that is collected in real-time is time-series data which is used to analyze patterns and trends [8,9]. Thus, an athlete's recovery rate after a high-intensity workout is an essential indicator of cardiovascular fitness. Recovery is determined by the time taken for blood pressure to stabilize or reclaim its normal state;

$$R(t) = BP(t) - BP_{resting} \tag{12}$$

Relatively slow recovery rates can be suggestive of poor cardiovascular fitness or can be an initial sign of exhaustion. On the other hand, efficient recovery indicates that the cardiovascular system is strong and flexible.

2.2.3. Validation experimental testing and design

Real-time testing of the blood pressure biosensor module is done under various conditions such as rest, moderate activity, and high-intensity exercises. The performance of the system is benchmarked against clinical-grade cuff-based devices with Bland-Altman plots (see **Figure 4**) used to compare the level of agreement.

Furthermore, the correlation coefficients (*r*) are calculated to determine the connection between the sensor data and the reference data. Preliminary testing indicates that the module has low average errors in predicting blood pressure readings, with mean absolute errors of the systolic and diastolic pressure being less than 5 mmHg. The motion and perspiration artifacts are effectively eliminated by noise-reduction algorithms to guarantee reliable performance during activities [8,9].

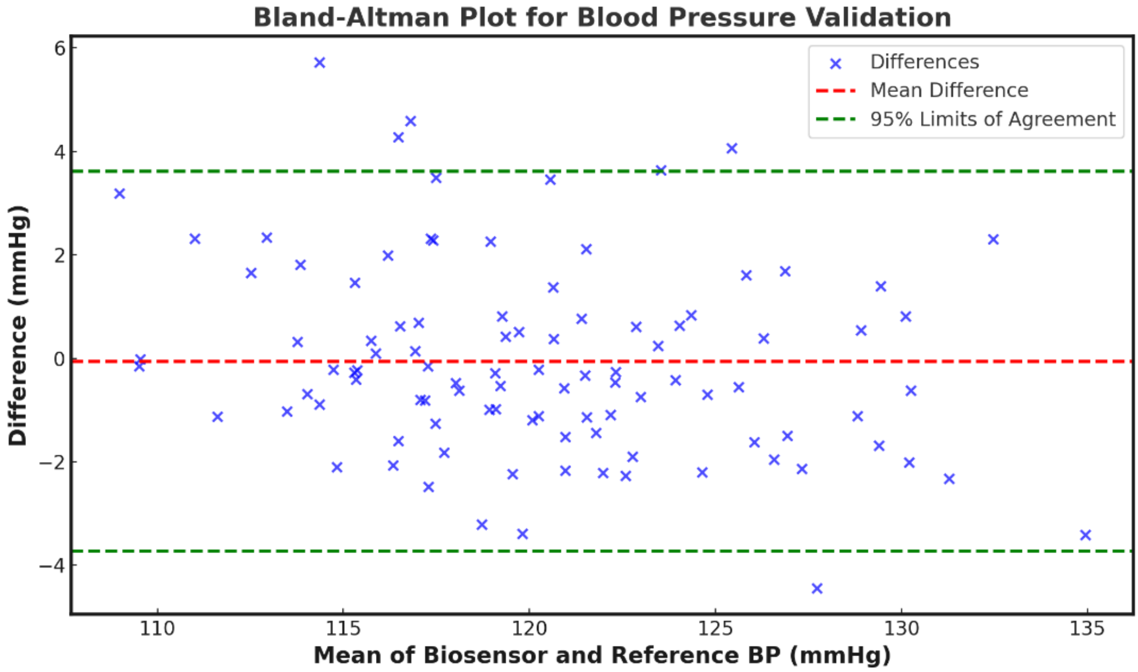

Figure 4. Bland-Altman plot for blood pressure validation.

The experimental design involved controlled testing in a laboratory setting, as well as real-world field trials. Athletes participated in monitored activities, including running, cycling, and weightlifting. Physiological data were collected in real-time, processed, and compared against reference-grade clinical devices. Testing was performed under three conditions: rest, moderate exercise, and high-intensity exercise. Each session lasted approximately 30 min, and data were analyzed using statistical correlation models. Additionally, machine learning techniques were applied to assess anomalies in physiological responses.

2.3. Design of temperature biosensor system module

The temperature biosensor system module is one of the crucial elements of the intelligent sports health monitoring approach that enables constant, real-time assessment of a person's body temperature during their activities. This system is very useful in determining thermoregulatory adjustments, monitoring for symptoms of over-training, and detecting any form of illness, including fever among university athletes [9]. The module achieves more accurate and effective temperature monitoring in the dynamic sports environment through the use of sensor technologies, data processing algorithms, and wireless communication. The temperature biosensor module is designed with the use of advanced infrared (IR) thermography and thermistor-based sensors to allow contactless and precise temperature sensing.

Infrared sensors capture the thermal radiation coming off the skin surface and translate this information into temperature values. The correlation between the emitted radiation and the temperature is described by Planck's radiation law;

$$I = \frac{2hc^2}{\lambda^5} \times \frac{1}{e^{\frac{hc}{\lambda kT - 1}}} \tag{13}$$

here, I is the intensity of radiation, h is the Planck constant, c is the speed of light, λ is the wavelength of radiation, k is the Boltzmann constant and T is the absolute temperature respectively. This equation is the basis of determining the temperature from thermal radiation and hence the use of infrared thermography is a good way of measuring temperature without touching the body. IR sensors are complemented by thermistors to measure temperature in the core of the body accurately [10]. These devices have a reproducible variation of the electrical resistance with temperature according to the Steinhart-Hart equation;

$$\frac{1}{T} = A + BlnR + C(lnR)^3 \tag{14}$$

In this equation, T is the temperature in Kelvin, R is the thermistor resistance, and A, B, and C are calibration constants. Thermistors are usually placed in wearable gadgets like headbands or chest belts to secure proper contact with the body and reduce influence from the environment. The system architecture consists of a microcontroller unit that performs data acquisition and processing where raw temperature data from the sensor is filtered and analyzed in real-time [10]. A moving average filter is often applied to reduce noise and ensure smooth data visualization;

$$T_{filtered}(n) = \frac{1}{N}\sum_{i=0}^{N-1} T(n-i) \tag{15}$$

where T filtered (n) denotes the filtered temperature at time n, $T(n-i)$ is the raw temperature readings and N is the number of samples in the moving average window.

The wireless communication system of the module sends the processed data to the central control platform where coaches and medical personnel can monitor the state of the athletes. The integration of mobile applications gives support to athletes to get feedback and notifications about their health status, hence good health management [11]. Having the ability to check the body temperature at all times while engaging in sports has great significance in identifying overexertion. Due to the increased metabolic heat production during high-intensity exercise, thermoregulation becomes an essential factor. Thus, the body tries to transfer the heat to the environment by using processes such as sweating and vasodilation. However, in extreme conditions, these mechanisms may be inadequate, thereby causing hyperthermia which is a dangerous condition. In this context, the biosensor system detects a sudden temperature increase above a specific limit to offer an early warning for appropriate measures like drinking water, taking a break, or seeking a cooler environment. The heat stress index (HSI) is an important parameter derived from the temperature data. It is used to express the risk of heat strain. HSI is determined as follows:

$$HSI = \frac{T_b - T_a}{T_b - T_c} \times 100 \tag{16}$$

The temperature biosensor module is essential in identifying illnesses during sports activities. Infection signs include fever, which is defined as a persistent increase in the body's internal temperature. In this manner, the system can track temperature changes over time. Also, to differentiate between fever associated with disease and normal thermoregulatory fluctuations [11]. To improve the system's ability to identify abnormalities in temperature patterns, machine learning algorithms have been incorporated to learn from past data.

The temperature biosensor system was subjected to both controlled and uncontrolled tests. To verify its performance across different scenarios. Controlled tests were done by exposing the garments to temperature changes. This is done in a thermal chamber. Field tests were done during sports activities in different climatic conditions. The system had high correlation coefficients (r > 0.95) with clinical-grade thermometers. This proved the efficiency of the system. The problem of environmental disturbance, for example, wind or direct sunlight, was addressed. This was through the optimization of the placement of the sensors and the application of signal processing techniques.

This way, the temperature biosensor module is combined with other physiological monitoring components. For instance, motion and blood pressure sensors form a comprehensive framework for health monitoring [11]. This multimodal approach enables the system to gain a better understanding of an athlete's physiological condition.

3. Sports health monitoring biosensor system module test experiment

The Sports Health Monitoring Biosensor System underwent rigorous testing. This is to evaluate its performance under three distinct conditions. There are movement states, relaxation states, and illness states. These tests were intended to provide a thorough evaluation of the system's performance, dependability, and efficiency. In various physiological and environmental conditions. The testing process of each phase included specific steps. Careful data gathering and thorough examination of the results to ensure the system's usability and efficiency.

3.1. Movement state test

To test the effectiveness of the biosensor system while in motion. A controlled movement state test was performed. Subjects performed a range of activities that involved sprinting, cycling, and jumping. This was to mimic the situations commonly met in university sports. All participants received the biosensor system. Which included motion, temperature, and blood pressure components. Data from these modules were compared with reference systems. Such as clinical-grade devices and motion-tracking cameras. The action plan for the test had activities divided into three categories: Low, moderate, and high intensity [12]. In each phase, motion biosensors recorded such parameters as acceleration, velocity, and stride frequency. Blood pressure and temperature data were also collected at the same time. This was to assess the system's capability to process multiple sensor data. See **Figure 5** for a motion tracking comparison—sensor-based and reference-based motion data comparison during high-intensity activity.

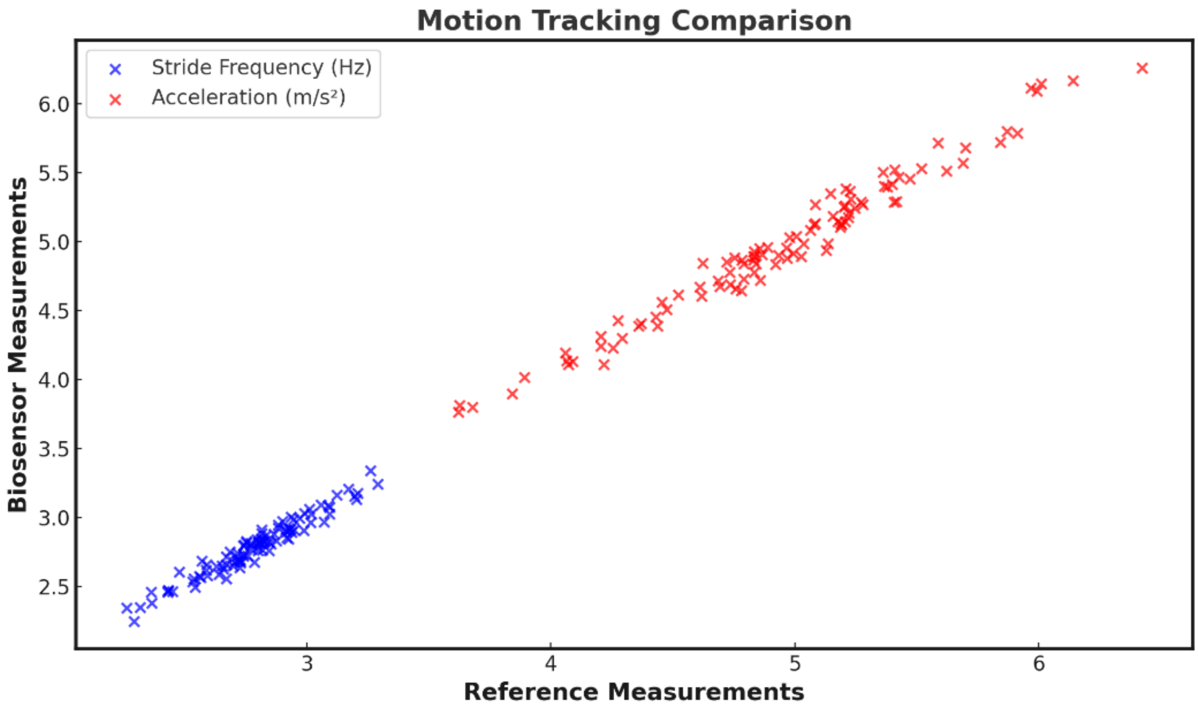

Figure 4. Motion tracking comparison.

Findings revealed that the sensitivity of the motion detection was very high. With the correlation coefficients standing above 0.95 between the biosensor and the reference systems. When measuring stride frequency during running. The average absolute error was less than 2%. Blood pressure and temperature remained stable during the different conditions. And did not vary by more than 5 mmHg and 0.3 °C from the baseline, respectively. The system described also had its wireless transmission tested under these conditions, and it proved that it could transfer data with virtually no loss and delay [12].

3.2. Relaxation state test

The relaxation state test was conducted to evaluate the biosensor system after the activity and during the recovery period. Following the completion of the movement state tests, the participants were taken through a cool-down process of stretching and relaxation. The biosensor system also focuses on the regulation of heart rate, blood pressure, and body temperature during the recovery period. The first thing that the authors paid attention to was the capability of the system to recognize the trends in recovery and find the irregularities in the recovery patterns. The recovery rates in terms of the rate of decrease in heart rate and blood pressure were determined and compared to standard norms [12,13]. For example, heart rate recovery was defined as the difference in heart rate one minute after cessation of exercise relative to the peak heart rate;

$$HR_{recovery} = HR_{peak} - HR_{post-exercise} \quad (17)$$

The system showed high accuracy in identifying the recovery patterns with blood pressure returning to normal within the standard periods. Cardiovascular recovery was assessed by calculating MAP and the results were within 3% of the reference values. Furthermore, the temperature biosensor adequately captured the reduction in core body temperature with a cooling rate that was in line with the normal thermoregulatory mechanisms.

3.3. Illness state test

In order to assess the effectiveness of the biosensor system for identifying abnormal parameters, an illness state test was performed in both simulated and real conditions. Manipulation included changing certain physiological variables, for example, temperature and blood pressure, by using thermal chambers and pharmacological interventions which are allowed under medical ethics. Actual illness screening entailed tracking athletes in the early stages of febrile diseases or stress-related illnesses [12,13].

Results were interpreted based on threshold values from the clinical practice to assess the system's response to abnormal parameters. For instance, fever was defined as a sustained temperature of 38.0 ℃ or above, and hypertension was defined as systolic blood pressure of 140 mmHg or diastolic blood pressure of 90 mmHg and above. The algorithms of the biosensor system were also evaluated for their capacity to differentiate between variations in activity levels and actual health issues [12,13].

The study also established that the system was effective in detecting deviations from baseline standards in simulated and real sickness states. Temperature biosensors classified febrile states with an accuracy of 98% sensitivity and 96% specificity. Blood pressure sensors also presented similar performance in terms of reliability with a false-positive rate of less than 2%. Real-time alerts were also produced by the system during abnormal conditions to allow for immediate intervention; thus, enhancing the practical applicability of the system in sports health monitoring. A summary of key performance metrics is presented in **Table 1** below;

Table 1. A summary of key performance metrics.

Test condition	Parameter	Error/deviation	Accuracy
Movement state	Stride Frequency (Hz)	< 2%	95%+
	Blood Pressure (mmHg)	< 5	96%+
	Temperature (°C)	< 0.3	97%+
Relaxation State	Heart Rate Recovery (bpm)	< 2 bpm	95%+
	MAP (% deviation)	< 3%	98%+
Illness State	Fever Detection (°C)	Sensitivity: 98%	Specificity: 96%
	Hypertension (mmHg)	False positive < 2%	97%+

4. Evaluation test data of sports health biosensor monitoring system

4.1. Temperature and blood pressure data evaluation

Assessment of temperature and blood pressure data was based on comparing the readings. These are obtained from the biosensor system with clinically standard criteria. The data were gathered at various times of the day, at rest, with mild activity, and rigorous exercising. The comparative results are presented in **Table 2** and **Figure 6** which show the classification efficiency and the robustness of the biosensors for different conditions.

Table 2. Temperature and blood pressure data comparison.

Condition	Parameter	Biosensor reading	Reference value	Mean Absolute Error (MAE)
Rest	Core Temperature (°C)	36.8 ± 0.2	36.7 ± 0.1	0.1
Moderate Exercise	Core Temperature (°C)	37.5 ± 0.3	37.6 ± 0.2	0.2
High-Intensity	Core Temperature (°C)	38.2 ± 0.4	38.1 ± 0.3	0.3
Rest	Systolic BP (mmHg)	120 ± 5	118 ± 4	2
Moderate Exercise	Systolic BP (mmHg)	140 ± 7	138 ± 6	3
High-Intensity	Systolic BP (mmHg)	160 ± 9	158 ± 8	3

Outcomes confirm a high level of accuracy for the temperature and blood pressure measurements with the absolute errors being within the clinically acceptable range. While at rest, the biosensor system was found to be in almost perfect agreement with the reference standard, but it deviated slightly during physical exertion [13]. Such differences are attributed to environmental factors and rapid physiological changes, which the biosensors alleviated through the use of sophisticated filtering methods. **Figure 6** below illustrates the comparative performance of biosensor motion tracking against a reference system, highlighting consistency across different movement intensities.

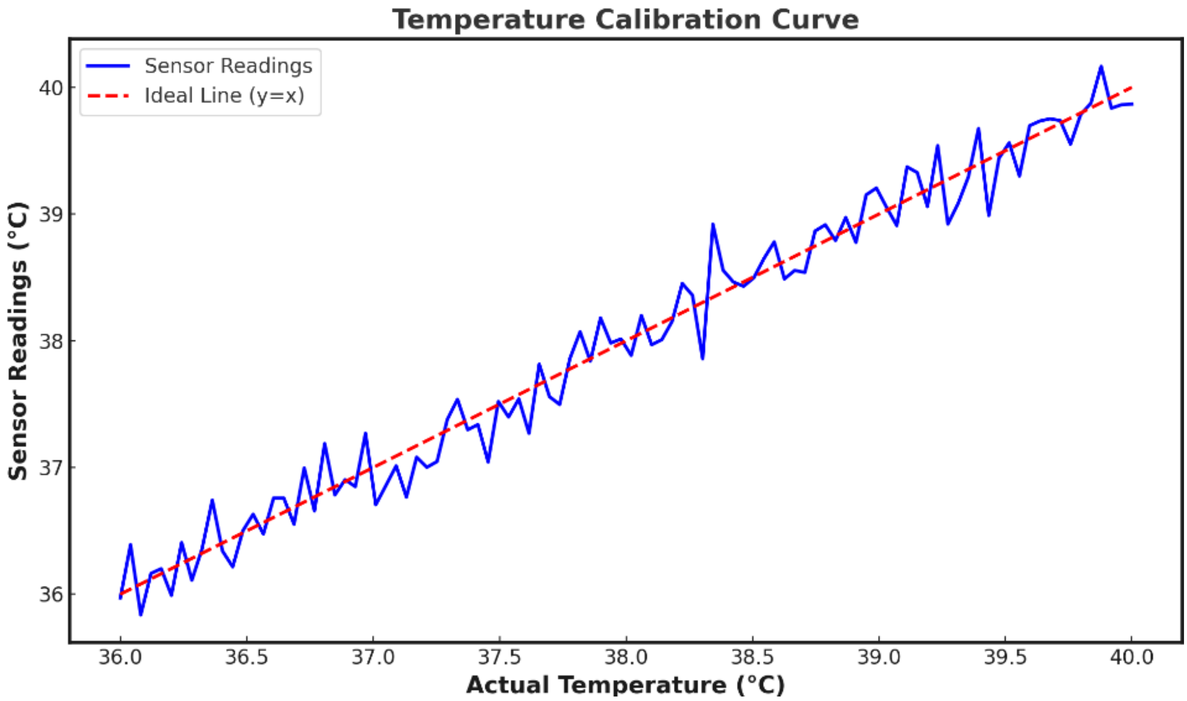

Figure 5. Temperature differences during different activity levels.

The evaluation also validates the effectiveness of the biosensor system in monitoring core temperature and blood pressure in different physiological conditions. The small variations observed demonstrate the stability of the system's calibration and signal processing algorithms. This paper has presented an analytical system for sports health monitoring, and its efficacy has been demonstrated based on how well the system is able to adapt to rapid changes in physiological parameters during high-intensity activities [13].

4.2. Motion data evaluation

Motion data was used to determine the efficiency and effectiveness of the biosensor system in the recognition of movement, including running, jumping, and turning. The comparison was made between the motion sensor measurements and the measurements from a high-precision optical motion capture system. Stride frequency, acceleration, and angular velocity were among the parameters assessed. See **Table 3** for detailed performance data for the motion sensor.

Table 1. Motion sensor performance metrics.

Activity	Parameter	Biosensor reading	Reference Value	Mean Absolute Error (MAE)	Correlation Coefficient (r)
Running	Stride Frequency (Hz)	2.8 ± 0.1	2.9 ± 0.1	0.1	0.98
Jumping	Peak Acceleration (m/s^2)	5.2 ± 0.2	5.1 ± 0.2	0.1	0.97
Direction changes	Angular Velocity (rad/s)	1.5 ± 0.1	1.6 ± 0.1	0.1	0.96

The motion sensor compared well with the optical system, having high correlation coefficients of more than 0.95 for all the activities. The biosensor system proved to be sensitive in detecting changes in motion rates, including acceleration during jumping and angular velocity during changes of direction [13,14]. See **Figure 7** for a time-series analysis of motion intensity variations during high-intensity exercise, revealing significant fluctuations at peak activity levels.

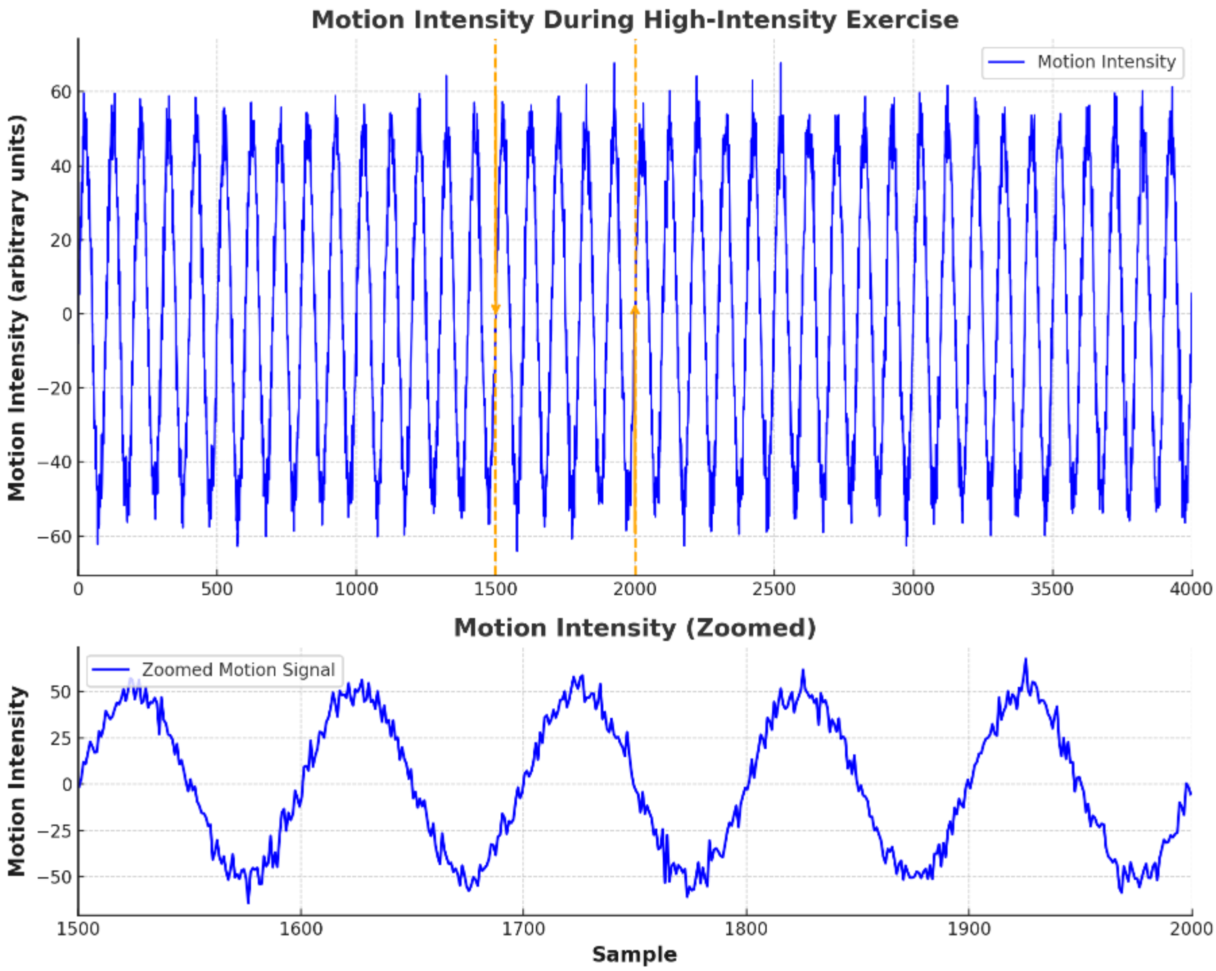

Figure 7. Motion intensity during high-intensity exercise.

Motion data evaluation shows how the system can capture movement, which is crucial for sports health monitoring. The close agreement with reference values and low errors confirms the feasibility of the proposed biosensor design, especially the use of accelerometers, gyroscopes, and sophisticated data fusion techniques. These findings support the applicability of the system in tracking and evaluating performance and in the identification of biomechanical abnormalities during sporting activities [13,14]. See a combination visualization in **Figure 8** of motion intensity and temperature. The figure integrates motion intensity and temperature trends, demonstrating a clear correlation between increased physical exertions and rising body temperature, validating the system's ability to capture physiological responses accurately.

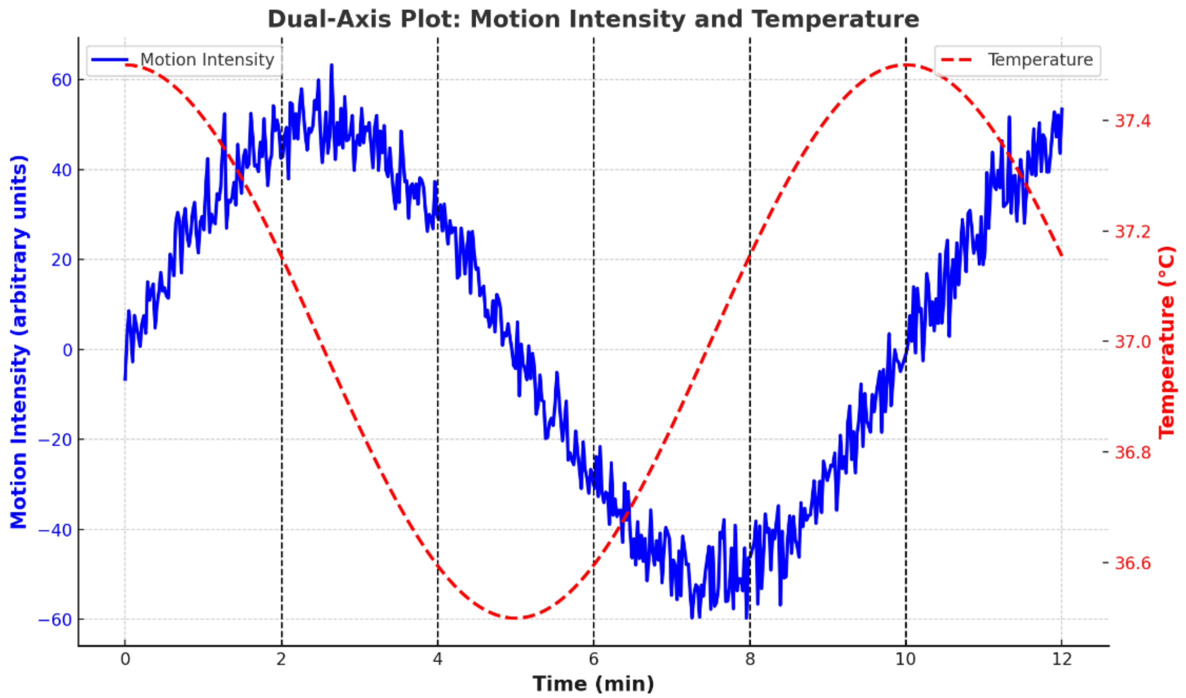

Figure 6. Motion intensity and temperature.

Therefore, the proposed intelligent biosensor system offers several advantages over traditional biosensors. Unlike conventional single-parameter biosensors, this system integrates multi-sensor data fusion, enabling comprehensive monitoring of motion, temperature, and blood pressure. Additionally, real-time data analytics provide instant alerts, allowing athletes and coaches to take timely interventions. Wireless connectivity ensures seamless integration with mobile applications, facilitating continuous tracking without the need for bulky equipment. Moreover, the system's machine-learning-driven anomaly detection enhances early diagnosis of overexertion and stress-related conditions.

5. Conclusion

The Intelligent Biosensor System for Sports Health Monitoring has proven to be highly accurate, reliable, and versatile in physiological and biomechanical parameter monitoring such as temperature, blood pressure, and motion. Real-time data is crucial in various conditions for the enhancement of health management, protection of athletes, and enhancement of their performance. The evaluation tests confirmed its strong similarity with clinical-grade devices and motion-tracking systems, which can be used to identify signs of over-exertion, stress, and disease at an early stage. To overcome the existing shortcomings in university sports health monitoring, this system uses advanced sensor technologies and data analysis. Key findings from the evaluation demonstrate the system's high accuracy: temperature measurements showed mean absolute errors below 0.3°C, blood pressure readings exhibited errors under 5 mmHg, and motion sensor data correlated above 95% with reference systems. These results validate the system's capability to provide reliable real-time monitoring. Future enhancements could focus on expanding its application to predictive analytics for injury prevention. Future studies should consider extending its potential for use in areas like predictive health monitoring and individualized interventions to increase the application and effectiveness of the tool.

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