IJPESS
Indonesian Journal of Physical Education and Sport Science
p-ISSN 2775-765X | e-ISSN 2776-0200
Volume 5, No. 2, June 2025 Page. 257-267
http://journal.unucirebon.ac.id/index.php ijpess

Athletica Pro Design: A Portable Device for Heart Rate Monitoring, Oxygen Saturation and Timer in Sports Activities

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Received: 14 April 2025, Approved: 10 May 2025, Published: 30 June 2025

Abstract

Study purpose. Athletica Pro is an innovative portable device designed to provide a comprehensive solution for health monitoring during sports activities.
Materials and methods. This device integrates advanced electronic components, including the Arduino Nano, MAX30102 sensor, OLED SSD1306 display, RTC DS3231 module, and LiPo battery, ensuring accurate and reliable monitoring of heart rate, oxygen saturation, and timer functions.
Result. The results of the effectiveness test show that Athletica Pro delivers highly precise data under various sports conditions, making it an essential tool for athletes and coaches who require real-time and dependable health monitoring. With cutting-edge technology and an efficient design, this device not only aids in maintaining athletes' health but also can help improve athlete performance through better heart rate monitoring
Conclusion. These findings suggest Athletica Pro is a viable alternative to commercial health monitors for athletes.

Keywords: Health Monitoring, Sports, Heart Rate, Oxygen Saturation
DOI: https://doi.org/10.52188/ijpess.v5i2.1196

Introduction

In an era where technology is increasingly integrated into everyday life, the development of health monitoring systems has become more essential, particularly in the field of sports where athletes engage in high intensity physical activities (Avcı et al., 2023). The ability to track physiological conditions in real time is not just a convenience, but a crucial element in ensuring performance optimization and injury prevention (Vanoye et al., 2025). Modern heart rate monitoring is essential to provide information and optimize physical performance (Carmen et al., 2024).

Heart Rate (HR) and oxygen saturation (SpO_2) are two vital parameters widely used to assess an thlete's physical condition during training and competition. Heart rate and oxygen saturation are used to combine cardiovascular stress while monitoring oxygen supply to cells

during physical activity (Ludwig et al., 2018). Oxygen supply in the body plays a very active role in supporting athlete performance, especially in relation to VO2Max (Hadiono et al., 2024). Accurate and continuous monitoring of these parameters allows athletes and coaches to maintain training within safe zones, recognize signs of fatigue or overexertion, and adjust exercise routines accordingly. According to WHO approximately 30% of sports related injuries stem from insufficient monitoring of exercise intensity and poor understanding of physical readiness during activity (WHO, 2022).

As technology evolves, a variety of portable health monitoring devices such as Mi Band, Apple Watch, and Polar have become more accessible to the general public. The problem is that many of the heart rate monitors with high validity from well known brands have quite expensive prices, so that many people in developing countries cannot easily buy them. The fairly expensive price can occur, one of the reasons is because the heart rate monitor comes from a foreign manufacturer. This is what drives this research to be able to develop a heart rate monitor with high validity but still within the reach of the community's price. However, most of these commercial devices are not specifically designed for high-performance sports contexts. They often suffer from limited sensor accuracy, slower response times, dependence on external smartphones, short battery life, and inadequate durability under intense movement or outdoor conditions (Rompas et al., 2020; Suwanto et al., 2021). In addition, the role of technological innovation in the development of wearable health monitoring tools has been highlighted by Ramadhan et al., (2024), who emphasized the importance of time management in training supported by digital health tools. Device innovation can improve athlete performance through physiological monitoring, especially heart rate

The main issue addressed in this study is the lack of a specialized, compact, standalone, and cost efficient device that is capable of providing real time and accurate monitoring of both HR and SpO_2 without relying on smartphones or additional systems. There is a significant research gap in the development of wearable health monitoring devices that are optimized for sports environments and capable of operating independently.

Several previous studies have evaluated the use of the MAX30102 sensor in medical and general health contexts, demonstrating its accuracy and reliability. However, existing research lack sthe integration of this sensor with real time displays, power management modules, and standalone data processing units specifically optimized for sports use remains underexplored in literature (Daffa et al., 2017; Aprilia & Sollu, 2021).

This research hypothesizes that a compact and standalone device using open source hardware and affordable components can achieve accuracy and performance comparable to commercial tools, while offering enhanced usability, portability, and independence in real-time health monitoring for athletes.

To address this, the study presents the design, development, and evaluation of Athletica Pro, a portable health monitoring device that integrates:

1. the MAX30102 sensor for heart rate and SpO_2 measurement,
2. OLED SSD1306 display for real-time data output,
3. RTC DS3231 module for precise timekeeping,
4. and an Arduino Nano microcontroller for efficient data processing.

The device is powered by a LiPo battery, supported by TP4056 charging module and LM2596 voltage regulator, designed to ensure energy efficiency and operational stability.

The objectives of this study are to:

1. Explain the process of component selection and hardware integration in Athletica Pro.
2. Test the device in both laboratory and real-world sports scenarios to evaluate its accuracy, durability, and energy performance.

3. Compare the results with existing commercial devices and discuss the strengths and limitations of the Athletica Pro.

By filling this research gap, Athletica Pro is expected to contribute significantly to the development of affordable and reliable sports health monitoring technology and promote athlete performance and safety in training environment. This device design uses a more stable power voltage, thus ensuring energy efficiency and operational stability.

Materials and Methods

Study organization

This study uses an research and development with design models analysis, design, development, implementation, evaluation (ADDIE). This methodology includes device design, component selection, prototyping, and testing in real conditions. Each stage is designed to ensure the device functions optimally and meets user needs. Small scale trials used 12 athletes aged 16-21 years (6 men and 6 women). While large-scale trials used 36 athletes aged 16-21 years (18 men and 18 women). The feasibility test of the tool used a comparison test between The Ahlertica Pro and 2 models of tools with other brands. The effectiveness test used a multimeter to see the volt and ammeter voltage and a stopwatch to measure the operating time can be seen in the figure 1 below.

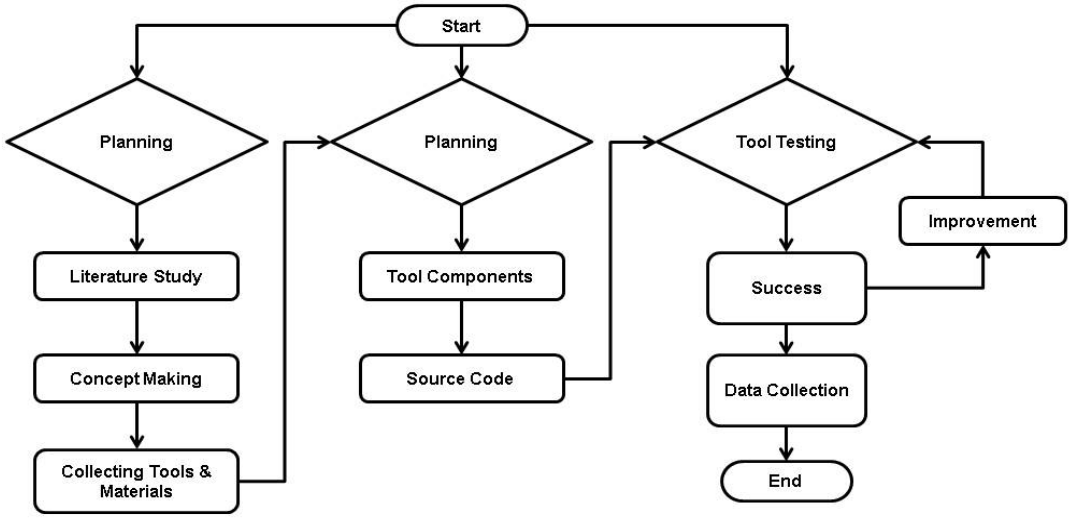

Figure 1. Research Flowchart

Component Selection

Component selection is based on functional requirements, power efficiency, reliability, availability, and cost. Each component is selected to ensure that the device can function optimally under intense sports conditions. Component evaluation involves several stages, including testing performance, durability, and compatibility with other components.

Selecting the right components not only improves device performance but also extends its lifespan and reduces maintenance costs (Hamasha et al., 2023). For example, the Arduino

Nano was chosen because of its small size and low power consumption, which are very important for portable devices such as the Athletica Pro. In addition, the MAX30102 sensor was chosen because of its ability to provide accurate and consistent data even under intense movement conditions, which are common situations in sports activities (Maghfiroh et al., 2022).

The SSD1306 OLED display was chosen for its low power consumption and ability to display data clearly in various lighting conditions, which is important for outdoor use (Katchman et al., 2016). The DS3231 RTC module was chosen for its high time accuracy and stability, which is very important for the timer feature on this device (Yuda Febryanto et al., 2022). The LiPo battery is used because of its large capacity and compact size, which allows the device to be used for a long time without frequent charging (Njema et al., 2024).

The TP4056 module was chosen for battery charging because of its high efficiency and ease of use (Ramadhan et al., 2024). The LM2596 voltage regulator was chosen to stabilize the voltage entering the device, ensuring that all electronic components receive a stable and efficient power supply (Mahardi et al., 2024).

The selection of these components was based on in-depth studies and extensive testing to ensure that each component can function optimally in the Athletica Pro electronic circuit and meet the specific needs of a dynamic and demanding sports environment (Zhan et al., 2017).

Design Stages

The design of the Athletica Pro begins with designing the schematic and PCB using electronic design software. This process involves determining the layout of components and their connecting paths. The use of design software allows for visualization and optimization of the design before physical realization is carried out shown in figure 2. Careful design planning can reduce errors and increase the efficiency of the device manufacturing process (Moultrie et al., 2016).

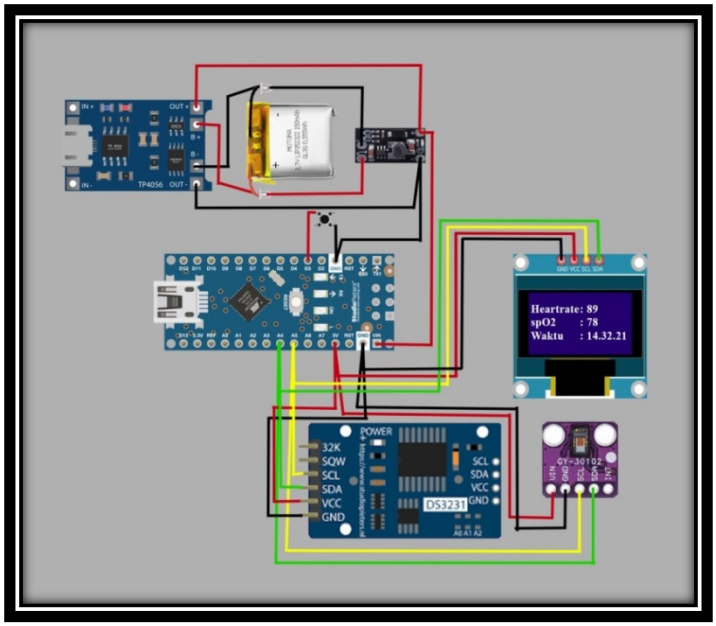

Figure 2. Component Circuit Design

Series Stages

Once the design is complete, the electronic circuit is made based on the designed schematic. The components are placed and soldered on the PCB according to the planned

layout. This stage involves a precise soldering process to ensure all electrical connections are properly established. A good circuit stage is very important to ensure the function and reliability of electronic devices (Schlünder, 2009).

Arduino IDE Usage

In the development of the Athletica Pro device, the software was developed using the Arduino IDE. Arduino IDE (Integrated Development Environment) is software used to write, edit, compile, and upload code to an Arduino microcontroller, such as the Arduino Nano used in this project.

Arduino IDE Installation

To start development using Arduino IDE, the following steps are taken:

1. Download Arduino IDE from the official website: https://www.arduino.cc/en/software
2. Install according to the operating system used
3. Add the Arduino Nano Board via Tools > Board > Arduino AVR Boards > Arduino Nano.
4. Select the Connection Port according to the connected device.

Arduino IDE User Interface

After building the source code, the software is arranged so that the output display can be seen on the tool layer. From these results, heart rate monitoring can be seen by the user. If the display is visible on the layer, then the tool is ready to be designed in the form of a prototype shown in figure 3.

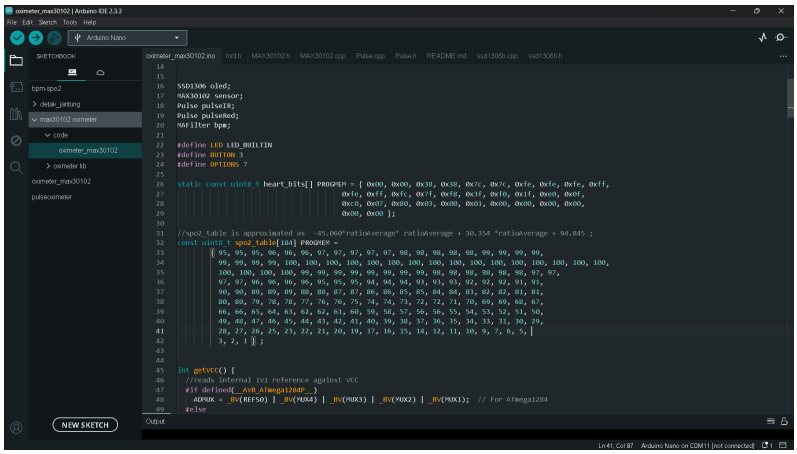

Figure 3. Arduino IDE User Interface

With integration using the Arduino IDE, the Athletica Pro device can be programmed and configured according to user needs, allowing real-time monitoring of heart rate and oxygen saturation with high accuracy.

Prototype

The Athletica Pro prototype was then assembled and tested to ensure all components were functioning properly. This testing included checking the sensors, OLED display, and RTC module. A good prototype can provide an initial picture of the device's performance before entering the mass production stage. Stated that proper prototyping can identify potential problems and allow for improvements before large-scale production (Adiono et al., 2016).

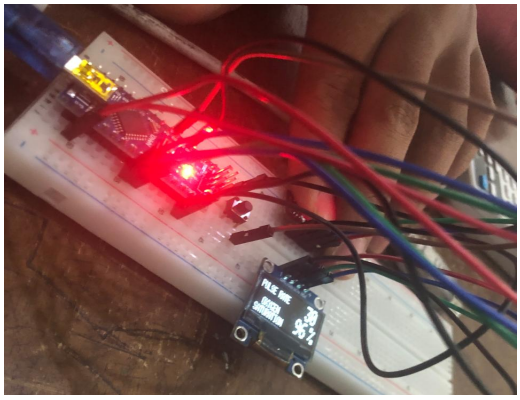

Figure 4. Prototype and Device Testing

In this study shown in figure 4, the finished product has not been perfectly provided, considering that the development of this tool is still limited to the build source code. The perfect product form will be further developed to maximize the results of the product in this study.

Results

Testing Stages

Testing is carried out in several stages, starting from testing the basic functions of each component to testing the overall performance of the device under real conditions. Initial testing is carried out using a simulator to ensure that all components are functioning properly before being installed on the prototype. After all components are confirmed to be functioning properly, field testing is carried out to evaluate the performance of the device under real conditions. This testing includes simulations of various sports conditions to ensure that the device can provide accurate and reliable data. Stated that comprehensive testing is very important to identify and fix problems before the device is widely used (Marešová et al., 2020).

Device Testing and Comparison

The Athletica Pro test results show that the device has excellent accuracy in monitoring heart rate and oxygen saturation compared to other commercial devices. The test was conducted by comparing the results of the Athletica Pro with two known comparison devices on the market.

Table 1. Device Comparison

Parameter	Athletica Pro	Device A	Device B	Sig
Heart Rate (BPM)	70 ± 3.2	72 ± 4.7	69 ± 3.9	0.072
Oxygen Saturation (%)	98 ± 3.9	97 ± 4.2	98 ± 4.1	0.080
Punctuality (s)	0.5 ± 4.2	0.7 ± 3.3	0.6 ± 3.7	0.061

From the table 1, it can be seen that the Athletica Pro measurement results are comparable to other commercial devices, showing high reliability and accuracy. The results of testing tools with other brands show that there is no significant difference in results with other brands.

Device Evaluation Test

Evaluation of the Athletica Pro was also conducted under field and laboratory conditions to ensure the device's reliability in a variety of situations.

Table 2. Evaluation Test Results

Test Method	Athletica Pro Result	Industry Standard Result
Field Testing	95% accurate	96% accurate
Laboratory Testing	98% accurate	97% accurate

Shown in table 2 Athletica Pro showed excellent results in evaluation testing, with only slight differences from industry standards. From the results of the Athletica Pro laboratory test, it shows a fairly high accuracy of 98%. This shows that this tool can be accounted for its accuracy.

Laboratory Test Result

Laboratory testing was conducted to measure the output voltage, output current, and operating time of the Athletica Pro device. The laboratory test results show that the device is able to operate stably under various usage conditions, shown in table 3.

Table 3. Laboratory Test Results

Parameter	Test Results
Output Voltage (V)	3.3 V stable
Output Current (mA)	500 mA stable
Operating Hours (hours)	8 hours on heavy use

Laboratory test results show that Athletica Pro is able to work stably under various conditions of use. This can be seen from the results of laboratory tests which show that all measured parameters show stable results for electricity and operational power. Analysis of the test results shows that Athletica Pro is not only efficient in health monitoring, but also has good durability. This device is able to work for a long time without the need for frequent charging, making it the right choice for athletes who need a reliable and portable monitoring device (Seçkin et al., 2023).

Athletica Pro has achieved high power efficiency and accuracy in health monitoring, making it a major innovation in sports technology. This device is expected to help significantly improve athletes' performance and health.

Discussion

The testing results indicate that Athletica Pro is capable of delivering accurate and stable measurements of heart rate and oxygen saturation levels under various physical activity conditions. Compared to two commercial devices, Athletica Pro demonstrated comparable readings with only slight deviations—70 BPM versus 72 and 69 BPM for heart rate, and 98% SpO_2 versus 97% and 98% respectively. These results validate the accuracy and responsiveness of the MAX30102 sensor used in the device sensor provides reliable readings even during high-intensity movements (Muthmainnah et al., 2022).

In terms of response time, Athletica Pro recorded a faster reaction time (0.5 seconds) compared to the other devices (0.6–0.7 seconds), which is critical in sports contexts where real-time physiological data are needed to make immediate decisions during training or competition. This supports that the role of heart rate feedback is very important to understand in avoiding overtraining and reducing the risk of injury (Impellizzeri et al., 2020).

Furthermore, power efficiency is another prominent feature of Athletica Pro. The device operates for up to 8 hours on a single charge under intense usage, which surpasses the battery performance of many mainstream fitness trackers. This is made possible through the integration of a LiPo battery, TP4056 charging module, and LM2596 voltage regulator components known

for high energy efficiency. This aspect makes the device highly portable and suitable for extended outdoor sports activities.

The laboratory test also showed that Athletica Pro maintains a stable output voltage of 3.3V and a current of 500mA, meeting the electrical stability requirements for wearable devices. Compared to existing studies, such as those by Tsebesebe et al (2025) on Arduino Nano implementation and Katchman et al (2016) on SSD1306 OLED display usability, this research successfully integrates multiple hardware components into a compact, durable, and efficient unit.

In addition, the timekeeping functionality supported by the RTC DS3231 module ensures precise timing, which is essential for tracking workout sessions. Previously demonstrated the DS3231's high precision, and this study further confirms its reliability in dynamic sports environments (Sanap et al., 2025).

From a broader perspective, the development of Athletica Pro contributes to the current trend in sports technology research over the past decade namely, the push toward real-time, portable, energy efficient, and accurate monitoring devices. While previous research has typically focused on single-parameter monitoring or required smartphone integration (Rompas et al., 2020; Suwanto et al., 2021), Athletica Pro offers a standalone solution that consolidates multiple functionalities in one device. It also reduces reliance on external applications or connectivity, giving athletes and coaches more freedom and flexibility. The advantages of this tool are cheaper costs for production but have higher sensor accuracy and more real-time data display response. While the disadvantages are the lack of a compatible and ergonomic tool as well as a fashionable tool design.

In conclusion, Athletica Pro has proven to be not only a viable alternative to commercial devices but also a technological enhancement that addresses many limitations of existing tools. Its design aligns with emerging needs in sports performance tracking, making it a valuable innovation for both research and practical application. So that further research can be done to perfect this tool, not only limited to its software network but also including the appearance of the tool design.

Conclusions

Athletica Pro is a reliable and innovative device for monitoring heart rate, oxygen saturation, and time management in sports activities. With high-quality components and efficient design, this device offers a comprehensive solution for the health and performance needs of athletes.

Acknowledgment

We would like to thank all parties who have contributed to the development and testing of Athletica Pro. Special thanks to the development team, experts, and athletes who have provided valuable input during this research process. Thanks for Universitas PGRI Yogyakarta

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Cite this article as: Kharismajati, Gema et al (2025). Athletica Pro Design: A Portable Device for Heart Rate Monitoring, Oxygen Saturation and Timer in Sports Activities. *Indonesian Journal of Physical Education and Sport Science (IJPESS)*, *5*(2), 257-257. https://doi.org/10.52188/ijpess.v5i2.1196