Sports Biomechanics

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***Abstract*—Biomechanics is the study of the structure, functionality, and motion of mechanical components in biological systems. Biomechanics is responsible for researching the internal structure, function, and movement of living things in order to perform certain tasks and interact with the physics of the environment. In this study, a prototype for a wearable body component that may transmit significant vital sign data is proposed. For biomechanical research, movement instruction, sports instruction, ergonomics lessons, and other uses, it captures natural movement. It makes it possible to consider the connections and interactions that different systems, components, and organs have with one another in order to examine how the functional structure of the human body functions. Nerve terminals in various body parts are used to calculate the proper biomechanical parameters.**

***Keywords*— Biomechanics, Galvanic, Depolarization, ESP32, Polymer.**

I. INTRODUCTION

Humans can adopt a range of positions and motions that enable them to move from one location to another or perform the locomotive function. Our musculoskeletal system, which supports the weight of the body and allows for movement of bodily parts, enables [11]. For physiotherapists to treat movement-related injuries or diseases effectively, biomechanics is regarded as one of the guiding concepts. Enhancing movement performance, reducing movement impairment, and treating illnesses or injuries connected to movement are some of the key uses of biomechanics. A study and analysis of professional players and sports in general using quantitative methods is called sports biomechanics. It can be summed up by calling it the physics of sports. Through mathematical modeling, computer simulation, and measurement, the laws of mechanics are utilized in this branch of biomechanics to better understand athletic performance.

Kinematics and kinetics are the two traditional subfields of biomechanics. The area of mechanics known as kinematics examines the geometry of an object's motion, such as its displacement, velocity, and acceleration, without taking the forces causing the motion into account. Kinetics is the study of the interactions between the forces acting on a body and the modifications in motion that these forces create.

Wearable sensor technologies are generating new commercial opportunities and application services that benefit common people all over the world [20]. There are various types of wearable sensors, communication, and remote service technologies, as well as security and privacy concerns associated with wearable devices, all of which are described in the research paper "Recent Advancements in Wearable Sensing Technologies"[21]. From a biomechanical perspective, our joints are impacted by the acceleration of many joints as well as the joint angle [9]. In order to measure tilt and steer a two-wheeled self-balancing vehicle, an accelerometer-gyro pair is employed [3]. Accelerometer (ADXL 345) that can gauge distance as well as identify and count steps. Distance traveled, calories burned, and to some extent, speed [8].

In our paper the user dons a vest that has all the sensors built into it in our proof-of-concept design. For user help on the phone or the website, data will be gathered and displayed.

II. LITERATURE REVIEW

The availability of accurate treatment plans and player-specific training regimens is made possible by the constant physiological data that wearable monitoring equipment can supply [7]. The essential controls we must maintain for good health are temperature, rate, and pressure level [2]. Musculoskeletal simulations of sports movements allow for quantifying variables that are difficult to measure in vivo. Since muscles are connected to multiple segments, their mass directly affects the effective inertia of the joints they act around. Joint kinetics is likely to be over- or underestimated by combining muscle masses with their nearest segment [11]. Although Artificial Neural Networks (ANNs) in sports biomechanics are considerably more commonly used in biomechanical analysis than expert systems, expert systems could be used as diagnostic tools for detecting flaws in athletic movements [1]. Implementation of a practical healthcare application using an ESP8266 wireless LAN module to connect to the cloud and an AD8232 pulse rate sensor backed by an IoT system [5]. To demonstrate the real-world practical ability of our VdW LM3 strain sensors, they have used them to monitor movement in the human body [6]. A force-sensitive resistor (FSR) that is capable of live shortening was encouraged by the idea of a replaceable, straightforward, non-invasive sensor. It is applied to the skin through a hard dome, which senses the mechanical force generated by the muscles underneath that are contracting [4].

From the biomechanical point of view, the influence of the acceleration of several joints and the joint angle affects our joints [9]. Tilt measurement by means of an Accelerometer-Gyro pair to regulate a two-wheeled, self-balancing vehicle [3]. Accelerometer (ADXL 345) which will recognize and count steps, as well as measure distance. Speed, distance, and to an extent calories burned by the user [8]. A piezoresistive sensor for mechanomyography and muscle contraction measurements, it teaches how to take FSR measurements, and when tested on healthy volunteers, the results are comparable [15].

From a biomechanical perspective, our joints are impacted by the acceleration of many joints and the joint angle. Our movement is also influenced by the sort of item we are wearing. For example, while designing and optimizing footwear, it is important to take into account how runners contact the ground. Updated research and development ideas for sports biomechanics may help with the creation of new running shoe models [10]. A pulse oximeter detects the quantity of light absorbed by the blood in capillaries beneath the skin to calculate the amount of oxygen in a patient's blood [13]. Blood pressure monitoring system using wireless technologies" ESP82766 module with wireless technology integrating a 27kpmh mini pump motor valve is used to calculate blood pressure. For displaying bp values wireless technology Bluetooth HC-05 is employed [17].

In today's world, approximately 75% of all employees are required to work in a seated position so an instrument chair with a force and accelerometer sensor with five different machine learning algorithms was developed to monitor their health benefits [18]. In a paper titled "Wearable sensor for reliable fall detection," the viability of employing a wireless network to detect fall events is demonstrated [22]. Also, to bring the benefits of wearable automatic tracing to strength training exercises is used by athletes and common people [23].

The methods utilized to develop our suggested system is described in the section that follows. The suggested approach integrates with the idea of sensors and the cloud, which is represented by a simple interactive BLYNK website. With interactive visualizations and a chart, the user may now have a thorough grasp of his body, which is a user-friendly manner to summarize our core goal.

III. METHODOLOGY

An IoT-based system has been proposed with interaction through the BLYNK platform, where you can view your real-time data, for analyzing your body during intense or regular exercise. We employed Node MCU, which is attached to the body, to process real-time data. The components required for designing of the proposed model are:

A. Sensors & Components

A fingertip is used to hold a pulse oximeter. It calculates the blood's oxygen saturation using laser beams. It is a tiny gadget that measures how efficiently an oxygen molecule binds to red blood cells by the refraction of infrared light. The heart's electrical activity is measured by the AD8232, a cute small chip. This QRS complex shows contraction and depolarization of the ventricles. By examining the waveform's individual components, ECGs can be analyzed. These waveform elements represent electrical activity in the heart. Galvanic skin response, or GSR, is a technique that could be used to gauge the skin's electrical conductivity. It is used to determine body posture and calculate calories. A force-sensitive resistor is a polymer thick film device that modifies its resistance in response to the force applied to its active surface. It is employed to compute the strength and contraction of muscles. Flex sensors measure the angle by force change. This sensor was used to calculate the arm angle while moving the muscles.

B. Algorithm

Algorithm
Input: Data from sensors (Fig. 1) Output: All the critical values are displayed on the web interface. Steps: 1. Setup: Initialization of all sensors (Fig. 2) 2. Initialize ESP32 to connect with the BLYNK cloud. 3. while (1) i. Read all the sensor values: heartbeat, blood pressure, muscle strain, and pulse oximeter. ii. Checking sensor values against the threshold. iii. Check threshold for UV sensor < display message. iv. Check threshold for heartbeat < display message. 4. Log the results on the web portal. 5. Output the FSR sensor, Pulse oximeter, ECG, Flex sensor, Gyroscope, and calorie reading on the BLYNK Visualization platform.

C. Block Diagram

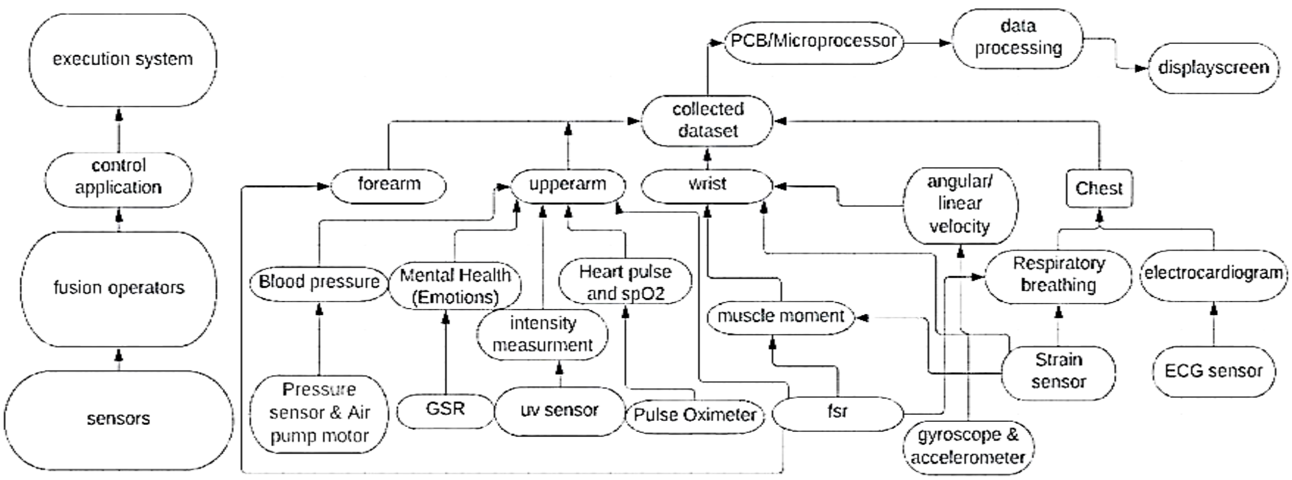

Fig. 1. Block Diagram

D. Flowchart

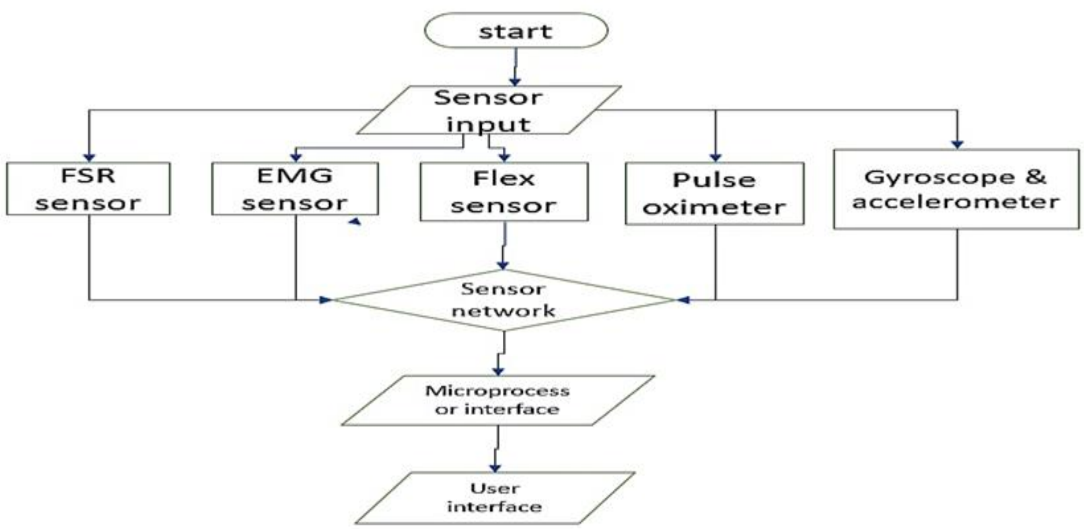

Fig. 2. Flow Chart

E. System Design

Hardware-based technology and software-based technology make up the two elements of the technique. First, the hardware configuration (Fig. 3), which integrates all the sensors. For suitable connections and data transmission via the internet, we connected the ESP32 to the pulse oximeter MAX3100, accelerometer and gyroscope MPU6050, UV GHYL 8511, flex sensor, FSR sensor, and ECG sensor in this case. The ESP32 requires some power supply in order to operate, therefore we utilized a power bank for it. The sensors were worn for a test, and the data was then entered onto a Google Sheet. The UV sensor's threshold was set at 3.5 mJ/cm2, the pulse oximeter's threshold at 94%, the heart rate range of 60 to 120 bpm, and the breathing rate of 12 to 16 breaths per minute.

Placement of sensors on the body is shown below (Fig. 3):

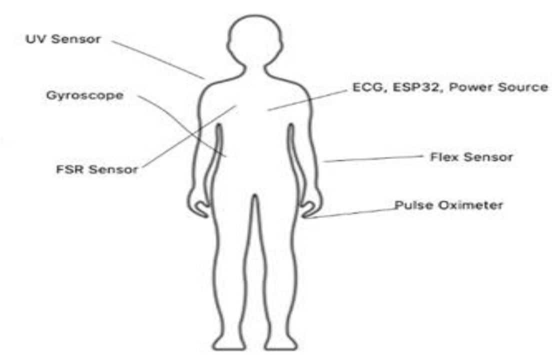

Fig. 3. Placement of the sensors

F. Database & Client Interface

The sensor network's data is stored and further viewed via an interactive interface (Fig 5, 6, 7 & 8).

For the collection of real-time data from the sensors, a Google Sheet is utilized as the database (Fig. 5). The data was transmitted over Wi-Fi after the sensor data had been gathered. The procedure of putting the data in the database is completely automated thanks to the usage of the Google app-script platform for rapid application development.

The interactive website where the dynamic changes in the sheet can be easily observed through the dashboard is further connected to the google sheet. When the threshold was crossed, we were able to modify the user through the interface using the observations and changes in the dataset.

Calories burnt by the user is calculated using:

$CC = \{MET * 7.7 * (BD * 2.2) / 200 \} * Duration/60$ -(1)[12]

It is then displayed on the interface(Fig 7).

IV. RESULTS AND DISCUSSION

The real-time monitoring of data from biomedical sensors is exclusively addressed in this one component of the proposed system. As NodeMcu has more digital ports than the esp8266, it was used to interface all of the paper's sensors. For the ECG and EMG sensors to forecast heart rate and muscle movement, respectively. The usage of an alert system helps to keep the user's biomechanical parameters(for the set threshold) as close to optimal as possible. Utilizing the BLYNK IOT platform, a comprehensive online and mobile interactive GUI (Fig 6) is created, and all sensor data is transferred to the channel via the authentication key for the user's final visualization. All the newly gathered data is also added to the Google Sheet for upcoming analysis.

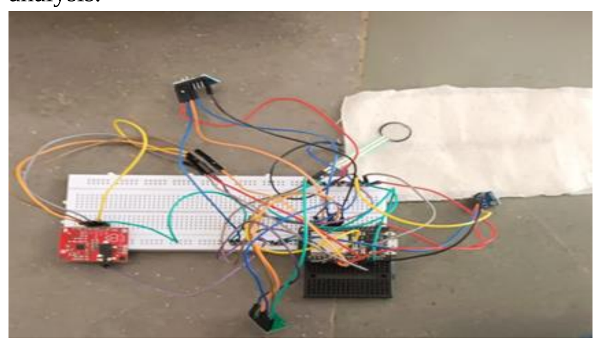

Fig. 4. Proof of Concept

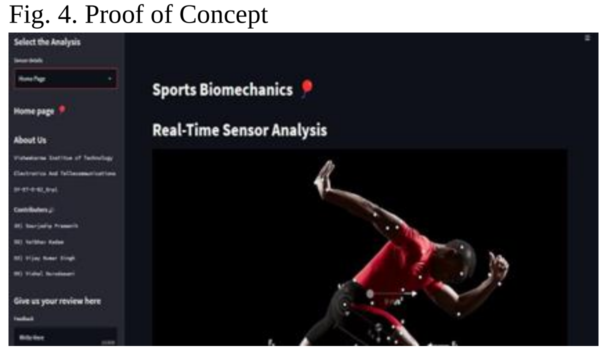

Fig. 5. Website Interface

Fig. 6. Oxygen Saturation and Heart Rate reading on Sports Biomechanics Portal

Fig. 7. Body orientation measurement on Sports Biomechanics Portal (Gyroscope)

Fig 8. Muscle Strength Analysis on Sports Biomechanics Portal (Flex sensor)

VII. CONCLUSION

The paper presents a novel, affordable, and lightweight wearable health parameter monitoring device with remote monitoring. This portable device is intended to measure vital body parameters during any sports activity. The device is equipped with a cloud interface using the BLYNK platform for remote monitoring, logging, and critical health warning to the person. The proposed prototype provides reliable and accurate measurements compared to the existing medical applications. The sports biomechanics device is helpful in everyday monitoring and has the potential to create a positive impact on our daily lives. The system is implemented using ECG, FSR, Flex, Gyroscope and UV sensors and a connected ESP32 portable edge computing processor. The prototype is designed to measure oxygen saturation, heart rate, body orientation during exercise, calories burnt, UV radiation exposure measurement, ECG chart, and muscle flexibility analysis with an appropriate threshold set for all based on the standard mentioned in healthcare articles [6]. It performs real-time monitoring and stores the vital parameters on the BLYNK cloud platform in a user profile. The parameters are observed for their critical thresholds, if any undesirables change is observed then an alert is sent to the user.

The system can be further upgraded using wireless less to ensure a smaller form factor. This system can be extended to serve seniors people with other health monitoring such as blood pressure.

This system is useful to professional athletes to enhance their performance and manage pain. This system can be extended as an aid for persons with physical disabilities.

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