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# Need for Wearables in Generating EHRs for Physical Rehabilitation Sector, Pheezee® — A Case Study

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***Abstract**: In the era of digital health, electronic health records (EHRs) are becoming the norm for storing and analyzing patient data. Data not only aids in clinical decision-making but also has the potential to help in achieving better clinical outcomes during patient recovery. Recently, wearables are seen to play a crucial role in creating EHRs, especially in a home-based care setting where traditional bulky machines cannot be deployed for continuous monitoring of patients. Pheezee®, an USFDA-listed [510(k) exempt] novel prognostic app-based wearable device for the rehab sector, has established itself to have huge potential in generating patient-specific ailment records in a scientific manner, thereby establishing the concept of EHRs in a clinical rehab setting. It consists of range of motion (ROM) sensors and a surface electromyography (sEMG) bio-amplifier that can be used for assessment, monitoring, and tracking of the recovery of patients via shareable scientific reports. The objective is to integrate the multi-sensory information from the device into an EHR system through remote monitoring. Pheezee® acquires the movement and muscle contraction information in real-time and pushes the data to the cloud for postprocessing, thereby establishing a novel approach to introducing EHR in physiotherapy. The data is encrypted, stored in a secured format, and maintained through an effective database management system. This clinical data helps the healthcare providers track the patient's rehabilitation and propose patient-specific, tailor-made treatment protocols. In the future, this EHR data combined with AI/ML algorithms has the potential to be used not only for assessments but even for exact diagnoses. The AI/ML models can also open preventive and predictive clinical models for value-based insurance claims.*

***Keywords:** Rehabilitation; Wearable Sensor; Electronic Health Record; Evidence Based Practice; Patient Adherence; Recovery Tracking*

## INTRODUCTION

Wearable sensors, such as accelerometers and gyroscope-based devices, give real-time data on patient movements and can assist physiotherapists and physicians in the development of personalized treatment protocols and tracking of recovery [1]. Surface electromyography (sEMG) is effective in understanding muscle physiopathology, disease prevention, and planning intervention [2]. The World Health Organization's digital health plan underlines the necessity of patient engagement [4]. Digital technology has made it easier for patients and healthcare providers (HCPs) to communicate with each other periodically [3]. Electronic health records, essentially, represent longitudinal data that are gathered throughout routine healthcare delivery and are stored electronically [5]. Immediate transfer of the clinical data into the EHR is one critical element that was found missing in the design of the wearable sensor and its architecture [6]. Physical therapy (PT) is concerned with identifying and maximizing quality of life and movement potential within the spheres of promotion, prevention, treatment/intervention, habilitation, and rehabilitation [7]. With the rising requirement to keep clinical information systematically, physiotherapists too see the value of electronic record systems [8]. Big data is a new area in the field of physiotherapy with significant importance in research and clinical application. Data science can help in the value-based insurance claims and optimization of health insurance claims by prioritizing the outcomes and maintaining optimal documentation. EHR not only aids in improving the patient's end outcome but also reduces the likelihood of errors due to built-in decision support tools that aid in therapy planning [9]. Pheezee® can monitor performance, track adherence, and generate scientific patient reports with valuable clinical insights. The objective of the study is to integrate the data collected by Pheezee® into an EHR system in the field of physiotherapy to improve clinical decision-making and remote monitoring and thereby help establish better clinical outcomes for patient recovery.

## METHODOLOGY

### Data Source and Collection

Pheezee® is worn by the patient during physiotherapy sessions. It interacts wirelessly with an Android phone where range of motion [ROM] and muscle activity of the selected joint is acquired and displayed by the device [10]. A total of 826 users' data was acquired in a duration of four (4) years.

### Data Acquisition and Management

The data acquired by Pheezee® is shared with the Android app via Bluetooth protocol, which is then transferred to the cloud server where the data is encrypted, stored, processed, and eventually displayed in a report format [10]. **Figure 1** provides the overall data acquisition and storage methodology.

### Data Storage

Data storage refers to the process of storing the patient information in a system. This includes the use of the wearable sensor Pheezee for collecting an array of clinical data such as ROM, exercise adherence, and muscle physiology through sEMG sensors. The format used to store this data is .json (JavaScript Object Notation) is used due to its accessibility and compactness..

### Data Retrieval

Retrieving the data on time is essential for healthcare providers to make informed clinical decisions. This is made efficient by using a REST API (Representational State Transfer Application Programming Interface). This facilitates data retrieval by easy connection between Pheezee and the EHR. This helps the physiotherapist access the patient data whenever required and improves clinical decision-making and patient care.

### Data Security

Data security is critical in any healthcare application, particularly when it involves sensitive patient data.

Multiple security layers are used by the system to safeguard the privacy and security of data.

Storage technology and format

The system uses MongoDB, a NoSQL database, in addition to .json for data storage. MongoDB is especially useful for managing unstructured data that is common in clinical settings.

Security measures

(a) Server-Side Security: The implementation of a Security Hashing Algorithm, specifically Hash64, ensures that sensitive data is hashed before storage. This process transforms the original data into a fixed-length string, making it virtually impossible to reverse-engineer the original data from the hash.
(b) Hardware Security: To further enhance security, AES-CCM (Advanced Encryption Standard in Counter with CBC-MAC) is utilized. This encryption method ensures that data is securely transmitted and stored by encrypting it before it reaches the database. **Table 1** shows overall elements of data management.

### Data Visualization

Pheezee® dashboard is a comprehensive visualization tool that offers real-time updates and shows the EHRs. The data is visualized in a graphical format which shows patients' recovery from the baseline assessment. **Figure 2** shows the Pheezee® dashboard.

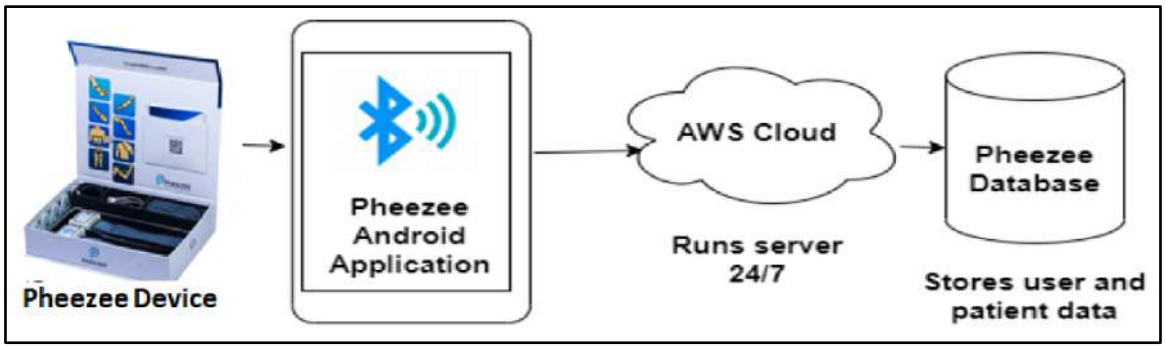


**Figure 1** Data transfer between device and cloud platform

**Table 1** Element of data management

| Storage | Retrieval | Security |
|---|---|---|
| **Format:** .json<br>**Tech:** MongoDB | **Format:** .json<br>**Tech:** REST API | **Server:** Hash64<br>**Hardware:** AES-CCM |

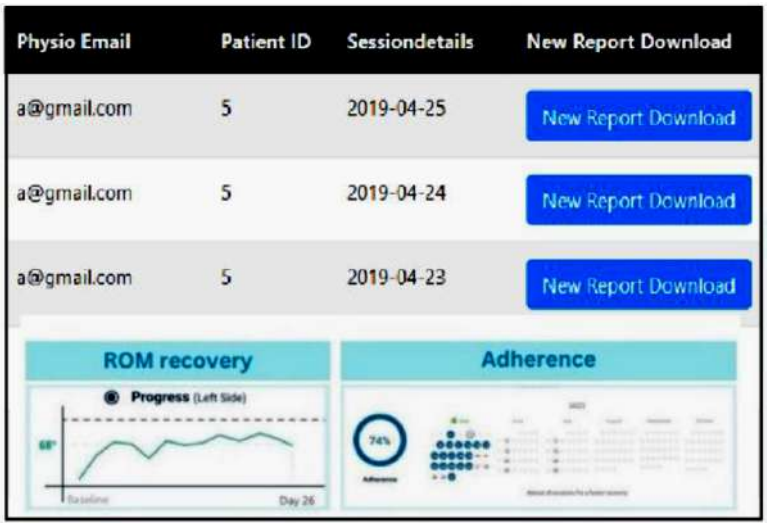


**Figure 2** Data visualization on the dashboard

## RESULTS

Data collected by Pheezee® was used to create patient specific EHR. Fig. 3 shows how Pheezee® EHR helps in clinical decision making and brings the physician, physiotherapist, and patient onto a common platform.

The custom-made software was designed to retrieve the EHR data when needed for the analytics. Pheezee® dashboard displays the patients' data and their corresponding clinical reports like physiotherapist's details, patient details, patient ID, session date, and number of sessions done etc. This extensive data set serves as a valuable resource for data-driven in-depth patient care and data-driven research. Pheezee® scientific reports give comprehensive information about the patient to the physician and the physiotherapist. For example, a male subject with an Anterior Cruciate Ligament (ACL) tear had undergone reconstruction surgery and was indicated for physiotherapy. The subject was assessed using Pheezee® every week for up to 10 weeks. This recovery process was remotely monitored and stored in the server as integral part of EHR. Post treatment, Pheezee® EHR showed 90% improvement in the primary knee muscles as compared to the baseline [11]. This process of monitoring and tracking using EHR, helped in timely intervention and helped in patient's recovery journey.

Additionally, Pheezee® EHR detects the overall adherence of the patient to the treatment protocol which ensures the treatment's success. Non-adherence in patients results in significant disease progression, mortality, and higher healthcare expenses [12].

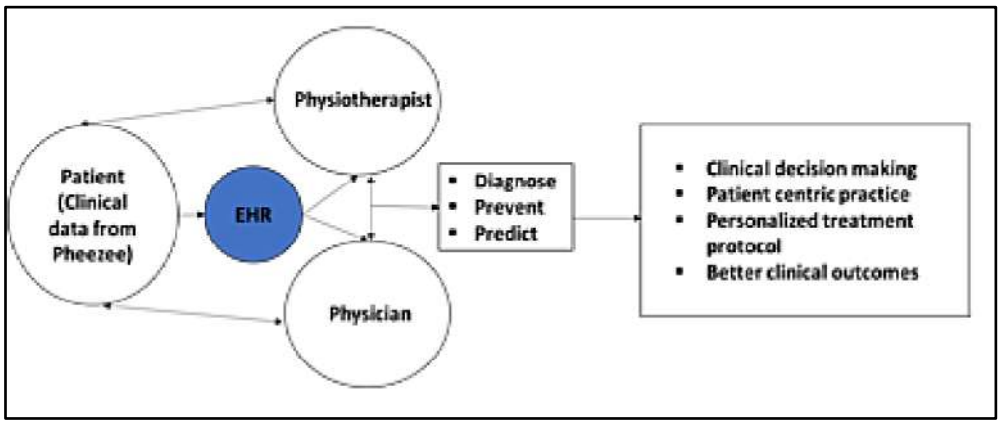


**Figure 3** Pheezee® EHR and clinical decision making

## DISCUSSION & CONCLUSIONS

This comprehensive data collected from the patient helped the physiotherapist in dynamic clinical decision-making for diagnosing and modifying the treatment. This process emphasizes patient-centric and personalized care. EHRs are increasingly being adopted instead of paper-based records due to their various advantages [13]. However, limited digital literacy of the user poses some challenge during the usage of the device. For neurological conditions, where prolonged monitoring is required this EHR-based analysis helps to secure the data for correlating with the period of recovery. EHR data in physiotherapy helps in applying value-based insurance plans for better patient experience and care. Physiotherapists benefit from the data for their day-to-day clinical decision-making process, tailor-made treatment protocol design, patient-informed and patient-centric care, and effective documentation. In future, this EHR system with big data analytics using state of the art AI/ML tools, has the potential to predict and prevent Musculo-skeletal & neurological ailments. Insights on data can assist policymakers in gaining a deeper knowledge of ailments to enhance the outcomes of policies implemented, boost the productivity of healthcare professionals. The principles outlined in the Helsinki Declaration of 1975 as revised in 2000 have been followed. This EHR data has the potential to enhance the value-based insurance coverage in the field of physiotherapy and rehabilitation.

### Clinical Relevance

Pheezee® has excellent accuracy in ROM and high correlation for sEMG assessments when compared with gold standards. The Pheezee® EHR helps to improve clinical decision-making and establish better clinical outcomes during patients' treatment and recovery period.

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