

NeuroCare: A Wearable Gadget for Headache Relief

Muhammad Saifuddeen^{1*}, Shabnaz², Ayesha Daniya², Sumayya², Rifah Sameen I Sarang²

Abstract

Headaches, particularly migraines, present a significant health challenge. Many individuals, especially students, suffer from frequent headaches that adversely affect their daily lives and academic performance. NeuroCare addresses this issue by offering a non-pharmacological treatment option through a smart helmet designed to provide headache massage therapy. The system's goal is to improve headache sufferers' quality of life by providing a practical, efficient substitute for conventional therapies. NeuroCare is a stylish, intuitive wearable gadget featuring cutting-edge neurostimulation and sensor technology. Its main purpose is to provide focused neurostimulation and relaxation therapy to relieve headache symptoms, such as tension headaches and migraines. Wearing the device around the forehead allows it to efficiently provide therapeutic vibrations and pulses to relieve the troubled area.

Keywords: Headache, migraine, massage therapy, mobile application, wearable technology

INTRODUCTION

Headaches and migraines are common neurological conditions that significantly affect the daily lives of individuals. These conditions can reduce productivity, disrupt daily activities, and decrease overall well-being. Traditional management strategies for headaches often involve pharmacological treatments and lifestyle modifications, which might not always provide immediate relief or be suitable for all patients owing to side effects or contraindications. This situation necessitates the exploration of alternative therapeutic approaches. In recent years, wearable devices have gained popularity in the healthcare sector because of their potential to monitor health parameters and deliver targeted therapies. The NeuroCare System exemplifies this trend by combining a smart helmet with a mobile application to administer targeted vibration therapy for headache relief. The NeuroCare smart helmet is designed with embedded vibration motors strategically positioned to target specific areas of the head, where pain is typically experienced. The mobile application allows users to input their symptoms, connect to the helmet via Bluetooth, and control therapy sessions. This system aims to provide a convenient and effective way to manage headaches, offering an alternative to traditional medication and enhancing user comfort and compliance. A critical aspect of the NeuroCare system is its ability to personalize therapy based on individual user input. The remainder of this paper is structured as follows: Section II reviews

the literature on wearable headache therapies and mobile health applications, highlighting the innovations and limitations of existing solutions. Section III details the system design, including the architecture, circuit design, flowchart, and user interface of the NeuroCare system. Section IV discusses the experimental setup and the results used to evaluate the effectiveness of the system. Finally, Section V concludes the study by summarizing the findings and outlining future research directions.

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LITERATURE SURVEY

Synowiec et al. [1] conducted a one-year study to evaluate the safety, utilization, and efficacy of

Remote Electrical Neuromodulation (REN) for migraine treatment. This study found REN to be a safe and effective long-term treatment option with minimal side effects. The participants consistently used the device and reported significant reductions in migraine frequency, intensity, and duration. These findings support REN as a viable noninvasive alternative for managing migraine over extended periods.

Blumenfeld et al. [6] conducted a systematic literature review of chronic migraine preventive treatments and assessed their effectiveness and safety. This review provides insights into the efficacy and safety profiles of various interventions, aiding clinicians in treatment decision-making. By synthesizing the existing evidence, this study offers valuable guidance for optimizing chronic migraine management strategies.

Lu et al. [7] conducted a literature study using data-mining technology to identify acupoints for tension-type headaches. Their research presented findings on the efficacy of specific acupoints in alleviating tension-type headaches. By leveraging data-mining techniques, this study provides insights into the selection and application of acupoints for headache management. This study contributes to the growing body of evidence supporting acupuncture as a complementary therapy for tension-type headaches, offering valuable guidance for practitioners and patients seeking alternative treatment options.

VanderPluym et al. [4] conducted a systematic review and meta-analysis focusing on acute treatment of episodic migraine in adults. Their research synthesized the existing evidence to evaluate the effectiveness of various acute migraine treatments. This study provides valuable insights into the comparative efficacy of different interventions, aiding clinicians in selecting the appropriate treatment options for episodic migraine management. These findings contribute to the optimization of acute migraine care and enhance outcomes in individuals with episodic migraines.

Goodhew [5] investigated migraine literacy and treatment among university students. This study examined the understanding and management practices of migraine in this population. This research highlights potential knowledge gaps and suggests avenues for improved education and support. This study informs healthcare providers and educators about migraine awareness and care needs among young adults in university settings.

SYSTEM DESIGN

The system design of the NeuroCare project involves integrating hardware and software components to create a seamless user experience for headache and migraine therapy. The design is divided into several key sections: system architecture, circuit design, system flowchart, mobile application interface, and helmet design.

System Architecture

The architecture of the NeuroCare system consists of three primary components: a smart helmet, a mobile application, and a communication interface. These components work together to provide personalized headache therapy to users. Figure 1 presents a conceptual diagram of the overall system architecture.

The smart Helmet was equipped with multiple vibration motors positioned at strategic locations on the head. The microcontroller controls the operation of the motors based on user input from a mobile application [6]. Mobile applications collect user inputs, manage therapy sessions, and provide additional health recommendations. The power supply supplies the necessary power to the microcontroller and motors.

Proposed Circuit Design

The circuit design involves an ESP32 microcontroller connected to multiple vibration motors via transistors, which control the activation of the motors. Figure 2 shows a detailed circuit diagram.

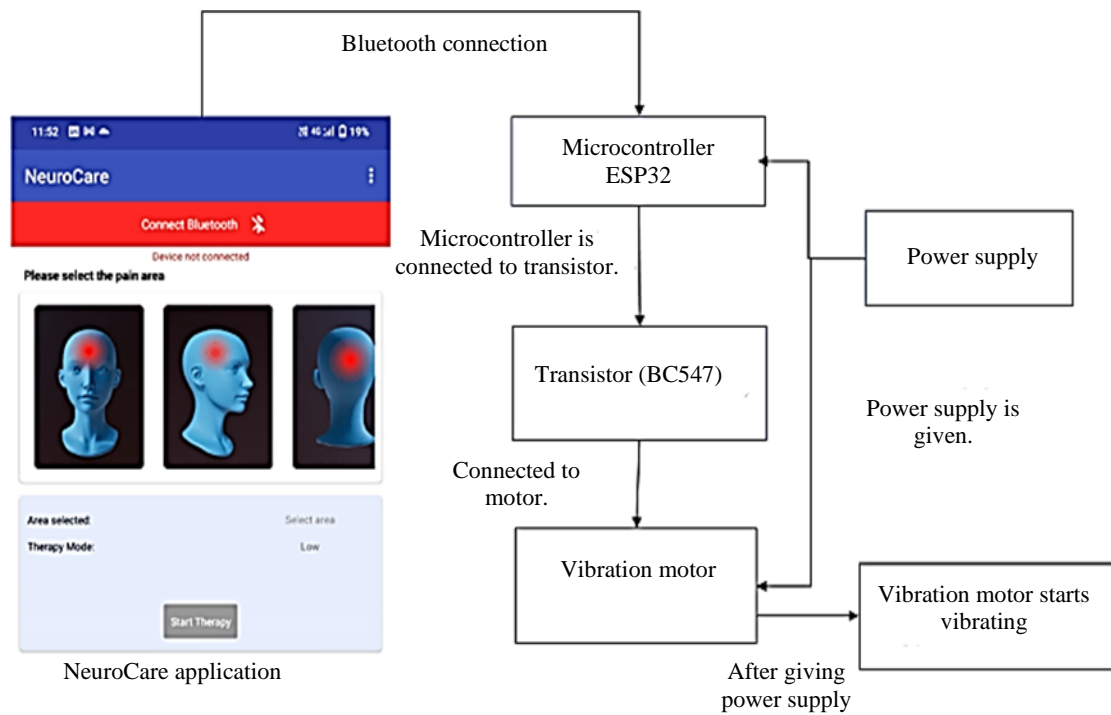


Figure 1. System architecture.

The ESP32 microcontroller acted as the main control unit. Transistors (BC547) were used to switch the motors on and off. Vibration Motors were positioned in the helmet at five specific locations to target different pain areas. 9 V battery with voltage regulators to provide 3 V and 5 V Power supplies [7, 8]. The ESP32 microcontroller was connected to the base of each BC547 transistor. The emitters of the transistors are connected to the ground, while the collectors are connected to the motors.

The motors receive power from a 3 V supply regulated by a 9 V battery. The circuit ensures that the motors receive power when the corresponding GPIO pins on the ESP32 are set high. Voltage regulators 7805 and 7833 step down the 9 V battery to 5 V and 3 V, ensuring stable operation of the microcontroller and motors.

System Operation Flow

The flowchart in Figure 3 outlines the step-by-step process from the user's perspective, detailing the interaction between the user and the system. The NeuroCare system begins with the user opening a mobile application on their smartphone. Upon launching the app, users are prompted to answer a series of questions related to their headache symptoms, such as whether they are experiencing vomiting, pain in the eye socket, or general headache discomfort [9].

The user then inputs the duration of the headaches. If the reported duration is more than two days, the application advises the user to visit a nearby doctor, providing location details of the nearest healthcare facility. If the headache duration was between one and two days, the application proceeded to the next step of therapy selection. Next, the user connects the mobile application to the NeuroCare helmet via Bluetooth, ensuring seamless communication between devices. Once connected, the user selects the specific area of the head that is experiencing pain from the available options (front, right, left, top, or back) [10]. Subsequently, the application initiates the therapy session, starting the vibration motors in the helmet at the designated pain area based on the user's input. The duration of therapy was determined by the intensity of the headache as reported by the user, with options for low (30 s), medium (45 s), or high intensity (60 s). Throughout this period, the corresponding motors screen to start a new session or exit from the application. Figure 3 shows the system flow.

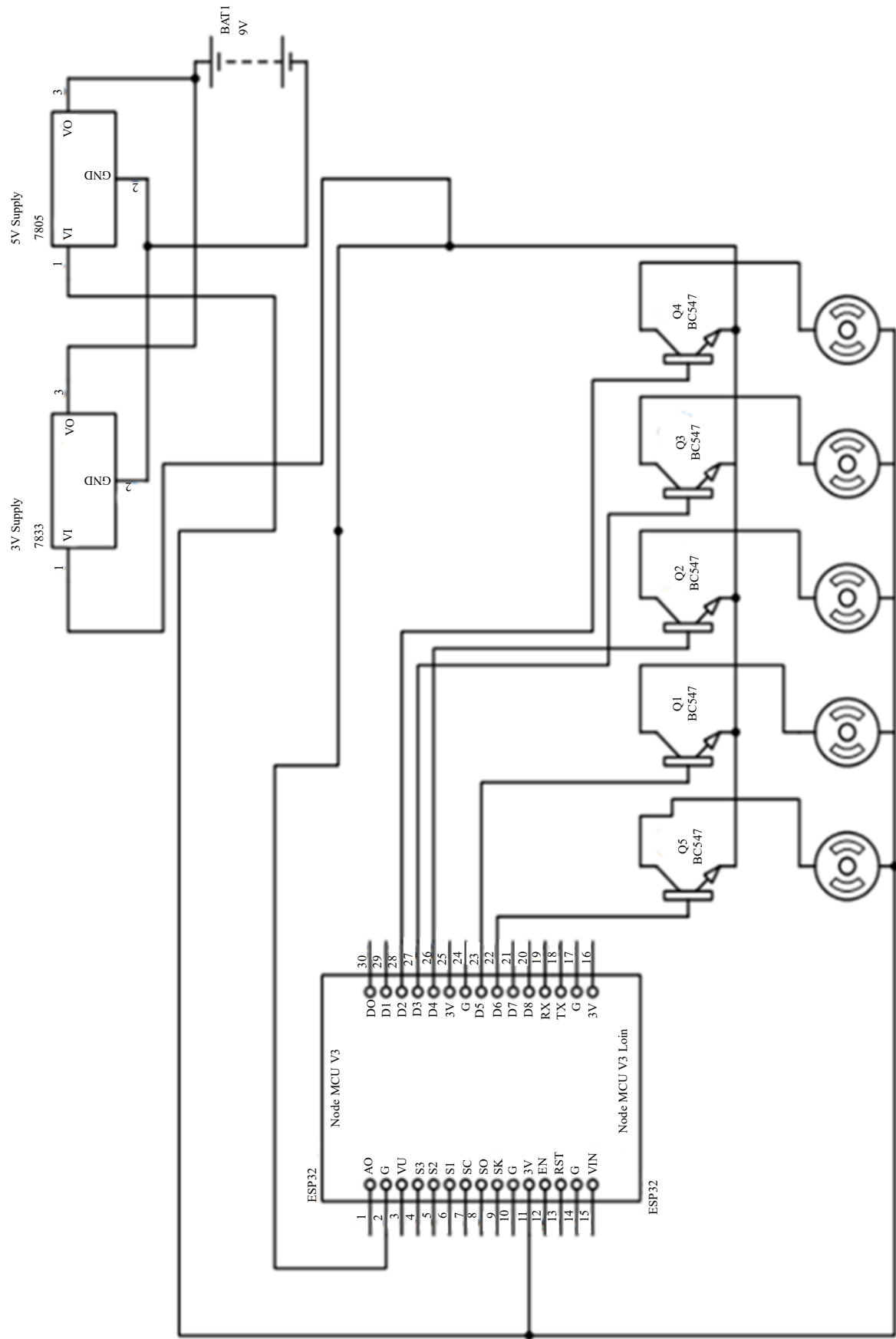


Figure 2. Circuit Design.

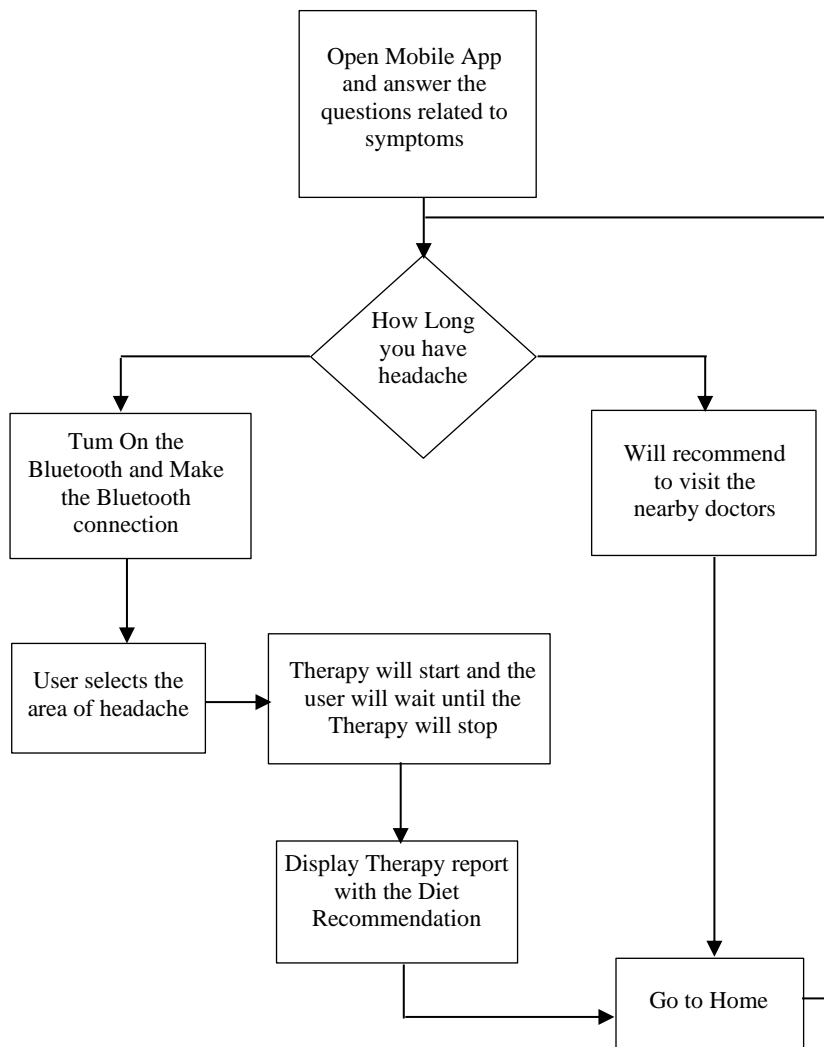


Figure 3. System flowchart.

RESULT

Smart Helmet

The NeuroCare system shown in Figure 4 represents a significant leap forward in the realm of non-pharmacological headache therapy, seamlessly integrating advanced technology with a user-centric design to provide a holistic and effective solution for headache sufferers. The system architecture, comprising three primary components—the smart helmet, mobile application, and communication interface—functions synergistically to deliver highly personalized headache relief. The smart helmet is equipped with multiple vibration motors strategically positioned across the head to target specific areas where users experience pain. Controlled by a sophisticated microcontroller, these motors operate based on the detailed user inputs received from the mobile application. This application plays a pivotal role, not only in collecting user data but also in managing therapy sessions and providing additional health recommendations tailored to the individual's needs. By leveraging real-time data and advanced algorithms, the application ensures that the delivered therapy is both precise and effective. The communication interface facilitates seamless interaction between the helmet and mobile application, ensuring that user preferences and therapeutic adjustments are accurately conveyed and implemented. Additionally, the robust power supply ensures that the microcontroller and motors operate consistently and reliably, thereby delivering uninterrupted therapeutic benefits. This comprehensive and innovative approach addresses many limitations associated with traditional headache treatments, such as the dependency on medications and potential side effects.



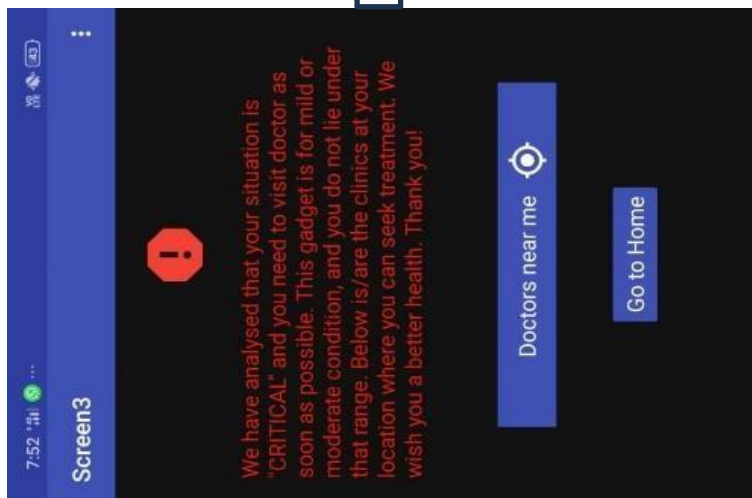
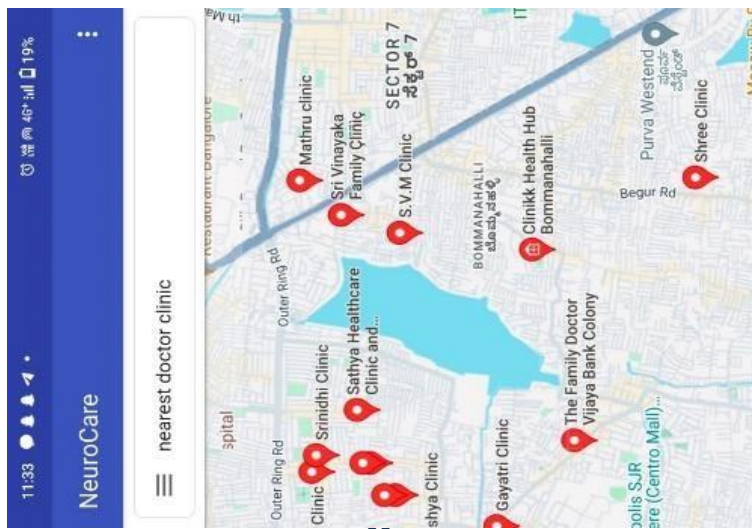
Figure 4. (a) Internal view of the NeuroCare smart helmet, showcasing the internal components, including the microcontroller, and wiring for the vibration motors. (b) Top view of a user wearing the NeuroCare smart helmet. (c) Front view of a user testing the NeuroCare smart helmet. (d) Side View of a user wearing the NeuroCare smart helmet during a therapy session.

By offering a user-friendly, efficient, and non-invasive alternative, NeuroCare aims to significantly enhance the quality of life of individuals suffering from frequent headaches, empowering them with a practical and accessible means of managing and alleviating their pain. Through its thoughtful integration of technology and personalized care, NeuroCare stands poised to revolutionize headache therapy, providing a much-needed respite for headache sufferers worldwide.

NeuroCare Application

The NeuroCare system was rigorously tested, and the results indicated its effectiveness in managing headaches using a user-friendly, technology-driven approach. The system's operation begins with the mobile application, developed using Kodular, which successfully engages users by prompting them to input detailed information about their headache symptoms and duration, as shown in Figure 5.

The application efficiently processes these data to provide immediate recommendations, such as advising users to seek medical attention if the headache persists for more than two days. For headaches lasting one to two days, the app seamlessly transitions users to the therapy-selection phase.



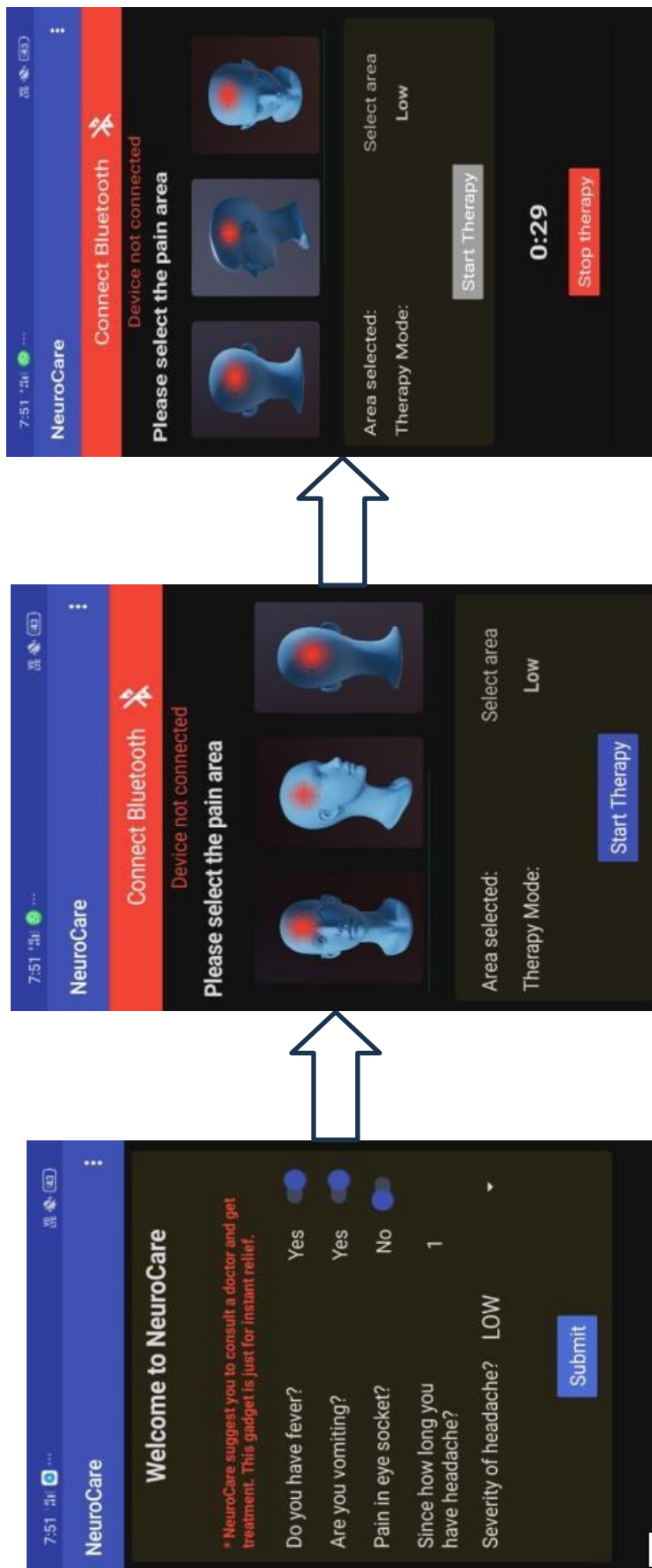


Figure 5. (a) Flow of the NeuroCare application when user reports headache duration of more than two days. (b) Flow of the NeuroCare application when user reports headache duration of less than three days.

Bluetooth connectivity between the mobile application and the NeuroCare helmet was found to be reliable, enabling smooth communication and control. Users can select a specific area of head pain and initiate therapy sessions without difficulty. The vibration motors in the helmet, controlled by the microcontroller, provide targeted massage therapy based on user inputs with durations tailored to the reported intensity of the headache. This personalized approach resulted in significant relief for users, as reported in post-therapy feedback. Finally, an analysis report is displayed, showing the diet recommendations for the morning, evening, and bedtime.

CONCLUSION

NeuroCare offers a novel approach for targeted headache and migraine therapy through a mobile application interface. This system was designed to deliver personalized massage therapy by leveraging modern technology for effective relief. NeuroCare is user-friendly and involves guiding users through symptom-related questions to determine the appropriate therapy. It allows for customizable therapy sessions based on the specific area of pain and intensity level and provides comprehensive post-therapy reports and recommendations. Our future studies will concentrate on a few crucial areas to improve and develop the NeuroCare system. We will further refine therapy protocols based on user feedback and data analytics to offer more personalized treatment options. We plan to extend NeuroCare technology to assist in rehabilitation services and provide targeted therapies for other conditions, such as neck pain or muscle tension. By integrating advanced data analysis tools, we can better understand user patterns and improve the effectiveness of therapies offered. Integrating our NeuroCare system with wearable devices, such as smartwatches, will provide continuous monitoring and more accurate tracking of headache triggers and therapy effectiveness. We aim to collaborate with healthcare providers and research institutions to validate the efficacy of NeuroCare and explore new therapeutic applications.

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