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Review Article

Wearable Connected Devices to Track the Body's Vital Signs

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Abstract

Systems for monitoring patients remotely are beneficial because they can deliver prompt and efficient medical care. Wearable sensor technologies that are highly developed and sophisticated are typically utilized to facilitate internet telemedicine. Vital sign measures like blood pressure (BLP), respiration rate, body temperature, and heart rate variability (HRV), collectively referred to as the electrocardiogram (ECG), can now be monitored using wearable connected devices. Due to the constraints of IoT wearable sensor connections with a dependable and precise network, many cardiac patients in remote areas are unable to receive the necessary emergency treatment on time.

Keywords: Wearables Connected Devices, Heart Rate Variability, Blood Pressure, Body Temperature, Respiratory Rate.

INTRODUCTION

The National Heart, Lung, and Blood Institute (NHLBI) reports that weather with a heat index of 90 degrees or higher is responsible for an additional 1373 fatalities annually on average in the United States [1]. Although the world is seeing an increase in these severe temperatures, many workplaces have long tolerated them. According to data from the US Department of Labor, 344 work-related deaths resulting from environmental exposure occurred between 2011 and 2019 [2]. This figure, however, is thought to be far less indicative of the true number of heat-related industrial fatalities and injuries [3]. A worker's physical activity raises their body temperature and increases the metabolic energy turnover [4], which enhances their vulnerability to heat-related stress on the body. When the body is unable to expel extra heat, heat stress arises, increasing the risk of disease or damage for workers [3]. Headaches, nausea, weakness, disorientation, higher body temperatures, and decreased urine production are among the common symptoms of heat exhaustion [3]. Additionally, it has been demonstrated that heat stress raises systemic inflammation in the body, which is connected to a number of prevalent health issues [5,6]. Given the detrimental effects of this systemic inflammatory response, both immediately and later, heat stress is a significant risk factor for many chronic disease processes that affect workers. We need to be able to keep an eye on how heat affects employees given the consequences of rising temperatures in different parts of the world [7], [40–41]. The National Safety Council reports that 49% of firms have adopted wearable technology to check employee health risks [8], as well as to supposedly detect sweat rates and skin temperature [40, 41]. The body's natural reaction to heat stress is to raise blood flow to the skin's surface in order to facilitate sweating, which aids in cooling the body. In order to achieve this, blood vessels will dilate and the heart rate will rise, lowering blood pressure [9, 10]. In order to provide early detection of the effects of heat stress on the body, employers should implement a wearable device that can monitor both body temperature [40, 41] and heart rate simultaneously. This is because of the dangerous fluctuation in vital signs that are representative of physiological functioning. Reducing the number of work-related fatalities brought on by working in extreme weather, like heat, may depend on early detection. The current methods for limiting an employee's exposure to heat-related stressors center on estimating the worker's level of heat stress based on clothing, exertion level, and environmental factors like temperature and humidity [11]. Although groups like the American Conference of Governmental and Industrial Hygiene (ACGIH) establish threshold limit values (TLV) based on these factors, workers' reactions to heat are not tailored to their particular circumstances [12]. Monitoring each worker's physiological parameters is crucial to genuinely preventing heat-related injury, even though preventing heat stress based on environmental conditions is a good place to start [12]. To remotely monitor an individual, wearable sensor systems need three main components: hardware for data collection, hardware for communication, and techniques for data analysis [13]. Sensors that track perspiration [14–16], temperature (core, skin, and rectal) [12, 17], heart rate, variability, recovery rate [12], and perceived exertion are among the wearables linked to the prevention of heat stress [12]. Smart wearable sensors can be used to measure a variety of physiological parameters, including pulse oximetry, blood pressure, pulse pressure, respiratory rate, and electrocardiograph (ECG) tracing [18–23]. These measurements are then recorded in a data acquisition device and sent to a monitoring location. The raw data is often collected by body temperature sensing technologies using either photoconductivity, infrared, thermistor, thermoelectric effects, or photodetector technologies [24, 25]. By using these technologies, it was demonstrated that the core temperature could be estimated with high accuracy (MAE 0.297, MSE 0.133) based on skin temperature and skin perfusion [26]. Core temperature can also be monitored using a radiometer to measure the thermal radiation emitted from the body with high levels of accuracy [27].

RELATED WORKS

In order to extend the monitoring period, this article describes an Internet of Things (IOT)-based heartbeat rate monitoring device that is battery-powered and supported by a human kinetic energy harvester. The ECG is a stress or exercise type of device that can continuously track a patient's heart rate while they go about their regular lives, including running, jumping, and walking [28]. The objective of this study was to correlate the vital parameters; including ECG, pulse rate, respiratory rate, temperature, heart rate, oxygen saturation, and blood pressure; derived from Real Time Multi vital remote monitoring (RTMVRM) solution and standard vital monitoring methods in chronic ischemic heart disease patients, stable on medication [29]. The purpose of this study was to determine the usability of the Slate Safety (SS) wearable physiological monitoring system. Methods: Twenty nurses performed a common task in a moderate or hot environment while wearing the SS device, the Polar 10 monitor, and having taken the e-Celsius ingestible pill. Data from each device was compared for correlation and accuracy. Results: High correlation was determined between the SS wearable device and the Polar 10 system (0.926) and the ingestible pill (0.595). The SS was easy to wear and a handy tool for remotely monitoring several participants. Conclusions: The wearable Slate Safety device showed accuracy in determining the worker's heart rate and core temperature without limiting their range of motion. It also offered a platform for remote monitoring of physiological parameters [30]. This paper develops a real-time heart monitoring system taking into account data security, accuracy, cost, and ease of application. The idea behind the system is to give patients and doctors a two-way interface for communication. This study's primary goal is to make it easier for cardiac patients who live far away to receive the most recent medical care, as the low doctor-to-patient ratio may make this impossible otherwise. Under the guidance of experts, 40 participants (aged 18 to 66) are assessed on the developed monitoring system using wearable sensors while holding an Android device, or smartphone. Because of its quick speed, the performance analysis demonstrates that the suggested system is dependable and beneficial. The analysis revealed that the suggested system is affordable, dependable, and easy to use while guaranteeing data security. Furthermore, in emergency situations, the developed system can send warning messages to both the patient and the doctor [31]. This study aims to examine the significance of heart rate monitoring through wearable IoT devices. The literature study method was utilized in this study's data collection; a descriptive data analysis and a qualitative approach were also employed. The findings demonstrate the importance of using IoT wearable heart rate monitoring devices because they are highly beneficial for patient monitoring [32]. This paper focuses on the algorithms for HR evaluation and describes a system for signal acquisition and processing based on a wearable textile device equipped with sensors for measuring chest movement and one-lead ECG. These signals are gathered and sent by an electronic board to a PDA, which then sends them over WiFi to a home gateway, which generates the HR and RespR time series. The data is combined by the home gateway with additional vital signs that are gathered through various devices and sent in XML format to a central repository. From there, a clinical decision support system can use the data to identify early decompensation episodes. The system is prepared for more in-depth testing in an actual clinical setting after successfully completing an initial test phase [33]. This review covers the principles of cardiac signal generation and recording, wearable technology, advantages and disadvantages, with a particular emphasis on the precision and usability of commercial and medical-grade diagnostic equipment that has demonstrated encouraging outcomes in terms of value and dependability. Cloud-based remote monitoring and artificial intelligence integration [42–45] have been developing to speed up data processing, enhance patient convenience, and guarantee data security [34]. In this project, which was motivated by auscultation, a robust heart rate monitoring application and a wearable stethoscope with biocompatible adhesives were designed and put together. First, the adhesives' geometry was improved, and the device's benefits were compared to those of PPG. After that, it was shown on several body arteries. We ran algorithms to make our device resistant to noise from the surroundings and various motion artifacts. Finally, our device's accuracy for continuous heart rate monitoring when compared to the gold standard, an ECG, suggests that our system may offer new wearable technology that could enable early detection of mental illnesses or cardiovascular diseases associated with abnormal heart rates over a variety of time periods [35]. In this work, we present a wearable platform for monitoring heart rate in the 5G ISM band, which operates at sub-6GHz.

The custom-printed circuit board (PCB) for data acquisition and transmission, a patch antenna, and an aluminum-nitride piezoelectric sensor make up the proposed device. The results of the experiment demonstrate that the system that is being presented is capable of obtaining heart rate from the posterior tibial artery along with diastolic and systolic duration, which are associated with heart contraction and relaxation, respectively. With a system size of 20 mm by 40 mm and a weight of 20 g, this gadget is lightweight and appropriate for daily use. Additionally, the system enables the use of a single reader to monitor several subjects or a single patient simultaneously from various body locations. The encouraging outcomes show that the suggested system can be used for Internet of Healthcare Things (IoHT) applications, specifically for Integrated Clinical Environments (ICE) [36]. We present a new integrated portable device that uses Ethernet technology and the widely available internet to provide a convenient solution for remote body temperature and fingertip heart rate monitoring. Heart disease is becoming more common these days. In these situations, patients frequently are unaware of their true conditions, and while it is true that most diseases are curable if caught early enough, this is especially true in rural areas where access to doctors is often limited. We have attempted to create a system that could provide health-related information and assist a person in identifying these fatal but treatable illnesses. The system provides real-time data on body temperature and heart rate [40, 41], which are simultaneously recorded on the portable side and sent to the internet. This technology allows for remote monitoring of body temperature and cardiac health. In the end, this gadget will close the gaps between patients and physicians by offering an inexpensive, readily available human health monitoring solution [37]. This article designs wearable devices using Internet of Things and virtual reality technology to address the shortcomings of the traditional monitoring equipment that make it difficult to measure the daily physical parameters of the elderly and improve the accuracy of parameter measurement. This gadget measures four physical parameters that older people experience on a daily basis: blood pressure, exercise heart rate, plantar health, and sleep quality. Experiments are used to confirm the equipment and measurement method's viability. The experimental findings demonstrated a high degree of accuracy in the reflective photoplethysmography signal-based measurement method, with the subjects' heart rate mean and difference values essentially ranging around 0 BPM and showing good agreement between the estimated heart rate and the reference value. The correlation coefficient between the reference value and the Prs estimate in the blood pressure measurements was 0.81. With the highest correlation coefficient of 0.96 ± 0.02 for subjects' resting heart rates, the device used in the article had a high estimation accuracy; its estimation error rate was 0.02 ± 0.01. Subject B8's Pnth value was higher than that of subject B21's, and subject B8's symptoms were more severe, which was in line with the real circumstances. The wearable gadget was able to recognize the subjects' ocular characteristics and deliver relevant videos to aid in the subjects' slumber. The article offers a technique and tool that let medical professionals ask questions in real time and get user-generated health advice [38]. Examining sensors and transducers for stroke detection is the goal of this study. Preferred Reporting Items for Systematic Reviews (PRISMA) are used in this study's systematic literature review. After screening and selecting potential articles, 84 were found to meet the inclusion criteria. According to the research findings, artificial intelligence built on the internet of thought—which makes use of sensors and transducers—is presently initiating the development of sensors and transducers for stroke detection. Based on the development of tools that employ sensors and transducers for stroke detection, it is clear that optimizing these devices for this purpose requires careful application, close regulatory oversight, and ongoing innovation in order to help lower the global stroke rate [39].

CONCLUSION

This study has reviewed a large number of publications about blood pressure and heart monitoring devices. We have witnessed their technological advancements and the effects they have on modern society.

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