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"Wearable Sensor: A review of the future non-invasive technology for continuous oxygen saturation and heart rate monitoring"

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Abstract:

Heart rate at rest and exercise may predict cardiovascular risk. Heart rate variability is a measure of the difference in time between each heartbeat represents the balance between the parasympathetic and parasympathetic nervous systems and may predict adverse cardiovascular events. Textile-based systems are an attractive wearable technology opportunity because they can provide monitoring of key physiological parameters in a comfortable and unobtrusive format. A new system based on multichannel optical fiber sensor probes embedded in a tissue envelope is described. The system measures the photosynthetic photogram (PPG) at two wavelengths (660 and 830 nm), which is then used to calculate oxygen saturation (SpO2). With advances in technology and increased commercial interest, the range of telehealth monitoring systems has expanded. In this paper, we present a review of future non-invasive technology of continuous oxygen saturation and heart rate monitoring, wearable devices, pros and cons focusing on accuracy, ease of use of commercial and medical diagnostic devices, which have shown promising results in terms of reliability and value. The integration of AI and cloud-based remote monitoring has evolved to facilitate timely data processing, improve patient comfort and ensure data security. In order to achieve a reliable measurement without adjusting the position of the garment, four plastic optical fiber (POF) probes are used to increase the probability of obtaining a high-quality PPG due to the positioning of at least one of the probes over a blood vessel. Each probe transmits and receives light into the skin to measure PPG and SpO2. This multi-channel sensor has the potential to realize reliable, unobtrusive and convenient textile-based monitoring of both heart rate and SpO2during daily life.

Keywords: wearable technology, wearable sensor, heart rate, heart rate monitoring, textile; plastic optical fiber, oxygen saturation.

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1. Introduction

Healthcare issues are among humanity's biggest threats. Over the past century, medical systems and practices have improved, extending lives by fighting illness. Regular physical exams and post-morbid visits help track many health concerns, but unexpected illness is still possible. Fast medical diagnosis and treatment have become primary priorities. Regular health monitoring helps us detect diseases early and avoid risks. Continuous hospital monitoring is easy, but limited medical resources and high medical costs are tough, especially in distant places. Successful solutions include non-invasive health monitoring for on-time detection, data collection, and first diagnosis to detect illnesses early and promote public accessibility. [1].

HRV is frequently studied in clinical trials for various purposes. The availability of consumer-grade ambulatory heart rate measurement has increased non-clinical HR/HRV monitoring interest. Linear, non-linear, and, most recently, machine learning analytics can extract additional data. As wearable technology usage expands, it's important to understand physiological and technological variables and data supporting its use. Recent studies [2, 3] review devices and their potential uses. The data behind some elements of ambulatory HR/HRV monitoring using wearable devices may help us understand how to apply this unique technology in this industry [4].

This paper reviews upcoming non-invasive technology for continuous oxygen saturation and heart rate monitoring, HRV factors, and recording, processing, and analysis methods. Consumer-grade device facts, challenges, and opportunities will be explored after a historical outline. For reliable SpO2 monitoring, this research introduces a new optical fiber sensor probe that monitors PPG and contact pressure simultaneously. An epoxy patch secures the SpO2 measuring fibers and converts transverse stress into axial strain at the FBG.

2. Aim of the study:

This study aimed to examine the physiological basis of HR/HRV, as well as the technological qualities and usability of wearable HR/HRV monitors. Although significant progress has been made in some areas of this field (new sensors and analytic methods, including machine learning), additional research is necessary to validate their use in real-world applications (validation of accurate measurement of specific HRV parameters, large-scale prospective clinical studies for specific clinical conditions).

3. Wearable sensor technologies:

Smart wearable technology has grown rapidly, and bio sensing advances have made measuring easier. Advanced technologies and sensor concepts have helped miniaturize wearable medical equipment. Developing wearable sensors and processing devices allows bio signal monitoring. Combined biosensors in a portable device gained popularity. The use of so many modalities helps overcome biosensor limitations. Wearable gadgets use biosensors differently. Healthcare networks, sports, military forces, and environmental monitoring use wearable devices [5].

In recent years, COVID-19, cardiovascular diseases, cancers, and chronic illnesses have had a major impact on patients' health and must be monitored regularly. Critical care units must monitor heart rate, respiration rate, blood pressure, oxygen saturation, glucose, and body temperature 24/7. Wearable medical devices monitor vital signs and provide essential details for disease diagnosis. Ambulatory vital signs and long-term health monitoring are benefits. The data can speed up disease diagnosis and therapy.

Wearable health devices improve quality of life by identifying and predicting diseases. To remotely monitor and treat patients in emergencies, biosensor data is stored and transferred utilizing wireless communication protocols. Continuous, real-time physiological monitoring makes wearable technology promising in healthcare. It helps monitor people's fitness and serious health issues without disrupting their daily routines. Academics have spent years developing trustworthy wearable devices. These wearables assess heart rate, respiration rate, blood pressure, body temperature, oxygen saturation, and pulse [4].

4. Heart Rate and Heart Rate Variability:

Wearable medical devices help identify and anticipate diseases, improving quality of life. Wireless communication protocols are used to remotely monitor and direct patients in emergencies and give instant treatment using biosensor data. Because it continuously monitors physiological indicators, wearable technology has significant potential in healthcare. Monitoring people's fitness and serious health issues without disrupting their daily routines is crucial. Recently, many scholars have developed reliable wearable technology. This wearable device measures heart rate, respiration rate, blood pressure, body temperature, oxygen saturation, and pulse [4].

Resting and active HR can predict cardiovascular risk. The resting heart rate predicts cardiac disease, stroke, and sudden death [7]. HRV is the time difference between pulses that indicates parasympathetic and sympathetic nervous system homeostasis. HR and HRV are usually measured across 24 hours to allow for daily fluctuation. Continual monitoring eliminates sampling bias. A sudden heart rate change may signal a medical condition. Paroxysmal supraventricular tachycardia (a fast, irregular heart rhythm from the atria or atrioventricular junction) may cause transitory episodes [8].

HRV may predict adverse cardiovascular events in healthy people, especially after exercise, as well as in heart failure patients with decreased cardiac contractile function [9]. A lack of vegetive tone shifts (for example, in heart failure due to increased sympathetic and decreased parasympathetic tone, loss of respiratory variation) can induce low heart rate variability. Another abnormal condition is arrhythmia, or the presence of an artificial pacemaker. Changes in heart rate variability over time may precede clinically important occurrences. These can be assessed in individuals who have cardiac pacemakers, defibrillators, or subcutaneous loop recorders implanted. Atrial fibrillation, the most frequent continuous clinical arrhythmia, has recently become the subject of remote monitoring. Early diagnosis and treatment of this illness might help avoid consequences including ischemic embolic events (stroke). At first, AF is frequently asymptomatic. It possesses several characteristics that make it an excellent candidate for population-wide screening, including a relatively high prevalence (which increases with age and in the presence of common comorbidities), ease of detection (non-invasive cardiac rhythm or HR/HRV monitoring), and efficient and cost-effective treatment options. This arrhythmia is identified by irregularly irregular RR intervals, which can be assessed using techniques such as heart rate variability. Machine learning approaches could be used to detect AF.

In an ECG database study of 180,922 individuals, a deep learning technique (Convolutional Neural Network) diagnosed AF with 79.4% accuracy (sensitivity 79.0%, specificity 79.5%) [10]. The Cardiio Rhythm gadget detected AF from sinus rhythm in 217 individuals with 95% sensitivity and 96% specificity using non-contact photoplethysmography and a Support Vector Machine algorithm [11]. This section describes how qualified human interpreters with appropriate data presentation can diagnose some HR/HRV-related problems [4].

5. Sensors Used in Wearable HR/HRV Monitors:

ECGs or blood flow changes linked with cardiac activity can directly measure heart rate. Most commercial monitoring equipment uses photoplethysmography or ECG sensors. Sensor miniaturization enabled multi-modal sensing.

5.1 Photo Plethysmography (PPG):

Microvascular blood volume differences determine PPG. An emitter sends photon pulses through the skin, and a photodetector captures reflected photons, which record their varying intensity as a tachogram. Green and infrared LED lights and photodiodes assess wrist blood flow in the Apple Watch, a popular PPG-based device. The heart rate is calculated using 0.1-1 kHz sampling frequency and cardiac cycle variations to detect systolic events. The optical sensor moves 30-210 bpm. The sensor may also boost LED brightness and sampling rate to compensate for low signal levels. The green LED calculates walking average and HRV during workouts or "breathe sessions" while the infrared sensor measures background/baseline and notifies heart rate. FitBit wrist monitors employ similar LEDs.

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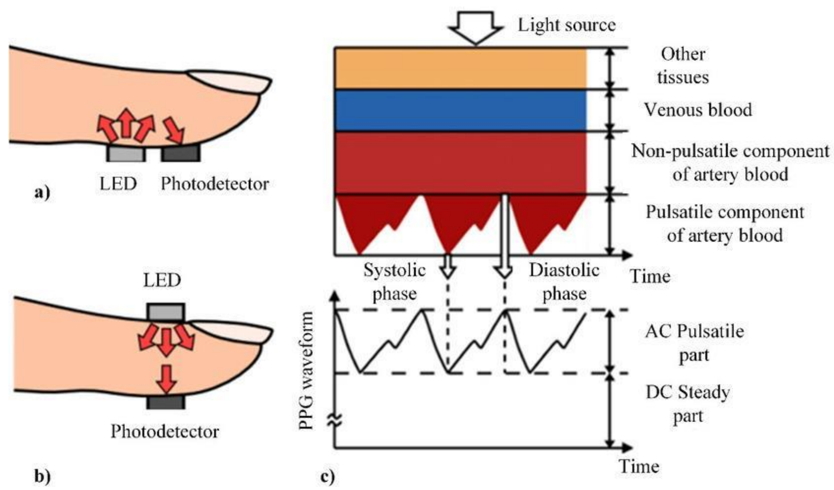

Figure 1: Principle of photoplethysmography (PPG) [104]: (a) reflective mode; (b) transmitting mode; (c) example of PPG signal.

5.2 ECG Based Sensors:

Clinical practice has utilized surface electrodes to assess cardiac electrical activity since the 1920s. The electrode-skin contact affects signal quality. Most clinical applications use wet Ag/AgCl electrodes, which reduce the resistance of the epidermis' last layers and maximize electrical voltage transfer between the skin and the input amplifier. Electrodes have adhesive to keep them in place. However, these may cause skin irritation over time.

This novel method uses dry electrodes without gel or adhesive. Due to skin-electrode resistance, sensor readout amplifiers with higher input impedances are needed for these more bearable electrodes [16]. Research is underway for dry electrodes using thin metal [17], carbon nanotube [18], and graphene [19]. PEDOT:PSS has high transmittance in the visible light spectrum, enabling transparent electrodes in wearable devices, and it is solution processable. Combining it with additives improves its conductivity, thermoelectric properties, and mechanical flexibility, allowing for optimization. Wearable ECG electrodes are waterproof, biodegradable, and last 2 weeks [20]. Wearable long-term cardiac monitoring applications may use a PEDOT: PSS composite elastomeric sponge electrode with reduced electrodeskin contact impedance, higher SNR, motion artifact tolerance, and improved wearing tolerability. These features enable long-term, high-quality monitoring without electrode replacement (Figure 2) [21].

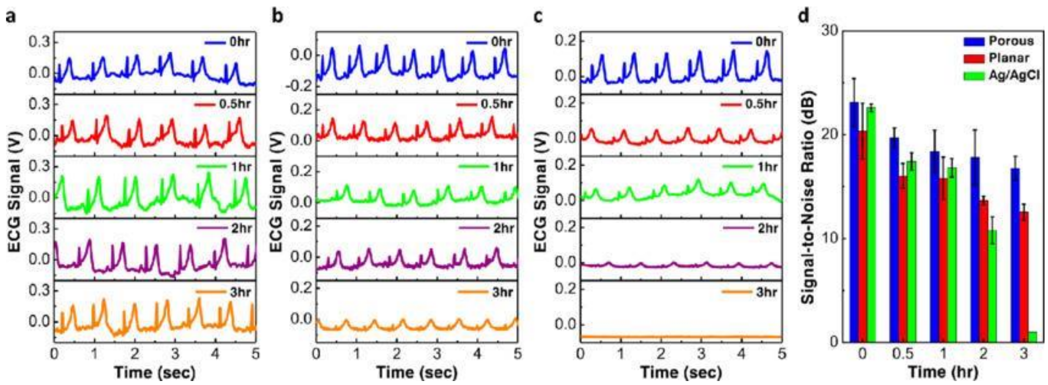

Figure 2: Long-term ECG signal recording.

ECG waveforms from porous PEDOT: PSS/PDMS electrodes, planar electrodes, and commercial Ag/AgCl electrodes at different times are shown in Figure 2. Comparing the signal-to-noise ratios of the three electrode types. In ECG-based wearable devices, improved electrode technologies that retain a good signal-to-noise ratio over time may reduce the need for electrode changes. This adapts [4]. The Creative Commons Attribution 4.0 International License covers the image (https://creativecommons.org/licenses/by/4.0/legalcode).

Capital electrodes, which can detect ECG signals from several millimeters distant without skin contact, are being widely studied since they can be implanted in garments or other items (flexible printed circuit board) [23]. These allow ambulatory measurement of non-cardiac biological markers such brain activity electroencephalograms.

Healthcare wearable ECG sensors collect many channels and analyze QRS shape and repolarization anomalies to detect conduction difficulties, premature beat location, and ischemia. One channel trace is enough for heart rate monitoring in consumer devices. Smart watches that record single-lead ECGs without patient input use the back of the watch as a positive electrode and the contralateral fingertip on the crown as a negative electrode [24]. ECGs are the best HR/HRV sensors.

5.3 Other Sensors:

Using accelerometers and gyroscopes, you can track your heart rate. Accelerometers record linear motion, while gyroscopes capture rotation. Sports benefit from this information. Besides motion detection, these sensors can provide data to ballistocardiograms (BCGs). BCG studies how each pulse shocks blood into the main arteries, causing the body to move [25]. The body's positioning affects acceleration-based sensors' accuracy [26]. Despite the lack of evidence, integrating barometers and GPS, which are available in consumer devices like smartphones, may improve activity-related HR/HRV fluctuations [27].

Implants may monitor temperature, thoracic or heart impedance, or minute breathing. Direct vegetative activity measurement and continuous blood pressure monitoring may be useful in ambulatory situations, but they are not currently feasible. CardioMEMS implanted devices remotely monitor and record pulmonary arterial pressure intermittently in ambulatory conditions to detect exacerbation and heart failure symptoms [4].

6. Wearable and smart textile technology for health monitoring:

Health monitoring with wearable and smart textile technology is a hot topic in the wellness industry. Diverse sensor technologies have been integrated into new devices [29,30] to provide reliable, covert surveillance. For continuous health monitoring, these systems using embedded discrete sensors in textiles present usability challenges. As an alternative to traditional methods of comfortable, unobtrusive physiological monitoring, optical fibers can be woven into clothes [31,32] to track vital signs including heart rate and oxygen saturation. Optical fibers have many benefits, including being inexpensive, lightweight, flexible, versatile, and sturdy.

Optic sensors in medical and fitness tracking systems use photoplethysmography (PPG). Blood volume changes are detected by PPG in transmission and reflection modes. Heart rate (HR) is measured with one wavelength and oxygen saturation (SpO2) with two due to the different absorption spectra of oxyhaemoglobin (HbO2) and deoxy(Hb) in blood [33].

Investigating multichannel PPG sensors with many sources and detectors addressed signal loss issues. One sensor detects PPG from the ear using three photodiodes (PDs) and two infrared LEDs [35]. The best PPG signal consistency channel was determined by these PDs and LEDs. Unlike a single-channel sensor, the sensor recognized the PPG during activity. A similar work used four IR LEDs and four PDs in a wristwatch [36].

The sensor's center has a single PD surrounded by cross-pattern and fastened multiwavelength LEDs. Different wavelengths of backscattered light help resist movement-induced displacement and misalignment. All of these multichannel PPG sensor systems use skin-surface optoelectronic components. Integration of optical fibers with fabrics, known as "photonic textiles" [39], increases user comfort.

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This article describes the first textile-based multichannel SpO2 measurement device deployment and study in human volunteers. Many optical fibers are utilized for pulse oximetry [40], however they are not integrated into textiles or use multichannel techniques. A cuff with four optical fibre probes detects wrist-reflected light at 660 and 850 nm. The sleeve's ability to receive signals without positional changes is being studied [28].

6.1 Optical Fibre Sensor for Simultaneous Measurement of Capillary Refill Time and Contact Pressure

After being blanched by external pressure, a distal capillary bed will take some time to refill and restore its normal color. In addition to its utility as a quick method for gauging cardiovascular risk, this test has also been proposed as a means of evaluating peripheral macrovascular disease and cutaneous microvascular illness [42]. Since its introduction in 1910 [32], CRT has found widespread application in the medical community as an indication of dehydration and surgical shock. Perfusion can be assessed with CRT [46], and researchers are looking into using it to assess tissue breakdown in the development of diabetic foot ulcers [47, 48].

Currently, there is no accepted standard method for assessing CRT [49]. Time taken for skin to regain its natural color after being blanched is the gold standard for measuring CRT [50, 51]. Fingers and toes are often convenient testing locations [52]. The results are likely to be inaccurate and imprecise because the actual blanching process is not standardized (e.g., pressure strength: light, moderate, or firm; pressure duration: 3 s, 5 s, or until the capillary bed clearly blanches) [53,54,55,56,57].

Recent automated measurements of this mechanism have found that skin pressure-induced fluctuations in reflected light can calculate CRT [58,59,60,61,62,63]. Because blood volume influences the reflected photoplethysmogram, it can compute CRT. CRT sensors were based on reflectance PPG sensors with a light source (LED) and photodetector [64]. Reflectance geometry-based sensors allow CRT measurement on anybody portion [65]. These designs did not account for blanching pressure, which could affect results depending on time and strength. Measurement of applied pressure and PPG concurrently can help identify normal and pathological CRT [66].

After receiving the reflected PPG signal, processed refilling signals can estimate the CRT. For CRT computation, an exponential fitting model of recovery period light intensity data was used [72]. Shinozaki et al. proposed a CRT measuring technique in 2017 that modeled the intensity waveform recovery phase as an exponential decrease and tracked the time it took the light intensity to return to 10% of its initial height above baseline after blanching pressure was removed [72]. However, the exponential regression model order and anticipated CRT were not fully studied [41].

6.2 Optical Fibre-Based Pulse Oximetry Sensor

SpO2, the proportion of oxygenated haemoglobin molecules in arterial blood, is an indicator of chronic circulatory and respiratory illness risk and must be monitored during anesthesia [73]. A non-invasive method for measuring SpO2, pulse oximetry was introduced in 1983 and became standard in US general anesthesia in 1987 [74].

PPG at two wavelengths (typically red and near-infrared) is used to measure SpO2 in pulse oximetry because HbO2 and Hb have different absorption spectra [75, 76]. The PPG signal, which has a small pulsatile component (AC) and a large static component, represents the intensity of light that enters or reflects biological tissues. Arterial blood light absorption causes PPG signals to pulse, while venous blood, bone, skin, hair, and tissue light absorption causes them to steady [77]. In pulse oximetry, SpO2 is calculated using the absorbance ratio (R) of pulsatile PPG signals (Iac) to static signals (Idc).

Pulse oximetry uses transmission and reflectance geometries [6]. The reflectance mode is more versatile than transmission, which is limited to extremities like the finger, toe, or earlobe. Scientists are interested in wearable reflectance pulse oximetry [78], and optical fibers can transfer light to and from the body [79, 80]. In magnetic resonance imaging (MRI), metallic components should be avoided [81]. Recent focus has been in integrating optical fibers into fabrics to create wearable photonic textiles for comfortable and continuous SpO2 monitoring [82, 83, 84].

7. Results:

As a result, it is preferable to construct an optical fiber sensor that can track both the PPG and the contact pressure [91]. This would enable detection of the contact pressure range where the probe is most effective for measuring SpO2. A Fiber Bragg Grating (FBG) can be utilized to develop a contact pressure measuring optical fiber sensing method. Periodic changes in the core's refractive index are the building blocks of an FBG [92]. For a given effective refractive index (ne) modulation, the wavelength (the Bragg wavelength B) of the light reflected by the grating is dictated by its period. Bragg wavelength changes due to vertical transverse tension, axial strain, or temperature-induced changes in grating period and refractive index. However, because the unencapsulated FBG sensor is insensitive to vertical transverse strain, its sensitivity can be increased by being encapsulated in an epoxy-based UV-cured rectangular block or patch [93]. Small transverse pressure variations (100 Pa) can generate a significant Bragg wavelength shift [41] due to the representation of the vertical transverse load of the applied pressure into a horizontal axial strain.

Challenges

Signal capture and event categorization (identifying each cardiac cycle) contribute to the precision of HR/HRV estimations. The recording needs to be constant and reliable, cost-effective, and as personally meaningful as possible to the person being monitored. Without the need for adhesives and the ability to be woven into clothing, modern electrodes and sensors have enormous promise. Few studies to far have demonstrated the accuracy of HR readings using consumer-grade wearable devices, and much less robust evidence supports their use for clinically recognized HRV analytic applications. Human mistake can occur in any method that requires the participant's consent. Even with medical-grade loop recorders and patient education, as much as 45% of monitoring is poor (failed recording or transmissions) [94]. Once further miniaturization and battery life is achieved, subcutaneous implants (similar to medical-grade loop recorders) with fully automated recording, data transmission, and processing may eliminate errors associated with subject noncompliance.

Still a data security problem. Medical equipment is standardized, but not public. Business practices safeguard consumer-grade wireless and internet-based communication equipment. These vary greatly by location. Even if data formats are hidden, communication protocols employ publicly available technology and encryption methods it can exploit. Data storage, transport, signal processing, and result communication pose security risks. Advanced data security technologies cannot prevent data breaches. Block chain technology has been tested to protect these sensitive data [95]. Health authorities control most medical equipment, and their performance, including data security, is consistent. Cyber security concerns and data breaches can affect implanted cardiac devices with remote monitoring or programming [96]. Hijacking proprietary programming and communication protocols is possible.

Pacemakers and defibrillators were the first to benefit from cardiac remote monitoring. Remote monitoring can relieve patients and caregivers of logistical burdens and uncover transient issues [97]. The technique is safe and easy, but the equipment and employees needed for remote monitoring raised concerns about its cost-effectiveness [98]. Semi-automated and automated data processing met demand. Artificial intelligence, which may surpass human translators in accuracy and keep prices low due to its scalability, has the potential to quickly enhance this area.

Pacemaker and defibrillator patients benefited first from cardiac remote monitoring. Remote monitoring reduces logistical stress on patients and caregivers and detects transient issues [97]. The equipment and employees needed for remote monitoring raised concerns about its cost-effectiveness, despite its safety and convenience [98]. Demand fueled semi-automated and automated data processing. Artificial intelligence may surpass human translators in accuracy and keep prices low due to its scalability, making this issue ripe for rapid advancement.

Another major issue is data integration into healthcare data management platforms and setting patient and healthcare professional expectations for data review and communication frequency. These clinical systems increased time-to-decision and inpatient care consumption in clinical trials and simulation models [99,100,101].

Wearable gadget effects on human outcomes of chronic illness were studied in a meta-analysis published in 2018. Only one trial demonstrated a statistically significant reduction in weight gain among those who wore wearable devices; no statistically significant reduction in cholesterol or blood pressure was detected [102]. These studies, in contrast to clinical trials, deal with much larger populations and less organized data collection, which can lead to unexpected challenges like counting unique participants, keeping track of how different data streams are linked to each individual participant, and maintaining participant adherence and engagement [103]. The Apple Watch and Fitbit both had similar issues throughout their testing periods. The knowledge gathered from these large-scale studies will be useful in future designs, especially in regards to data handling in electronic clinical trials. As the overall burden of cardiovascular disease increases, more research on efficacy and cost efficiency is necessary.

8. Conclusion

This study aimed to examine the physiological basis of HR/HRV, as well as the technological qualities and usability of wearable HR/HRV monitors. Although significant progress has been made in some areas of this field (new sensors and analytic methods, including machine learning), additional research is necessary to validate their use in real-world applications (validation of accurate measurement of specific HRV parameters, large-scale prospective clinical studies for specific clinical conditions). Common examples of these issues have been provided. Although novel sensor/electrode technologies with superior long-term signal-to-noise ratios are currently being developed, these technologies have not yet been validated by large-scale research. PPG-based devices are more user-friendly than ECG-based systems for long-term monitoring; however, they have consistently demonstrated less accuracy in HRV values than ECG-based devices. Using optical fibers woven into fabrics, photoplethysmography for heart rate and oxygen saturation monitoring can be performed discretely and comfortably. However, the accuracy of reflectance PPG measurements is contingent on sensor/skin mobility and skin surface placement. We demonstrated how to use a multichannel approach to acquire a highly precise measurement that can be incorporated into a textile, such as a blouse, particularly near the wrist.

The incorporation of an integrated probe has promise in enhancing the reliability of reflectance oximeters. The utilization of the probe holds significant potential in enhancing the optimization of garment fit for wearable electronics. The wearing of snug garments has the potential to impede user compliance, hence it may be preferable to administer an appropriate level of pressure without excessive tightness. The probe has the potential to be utilized in garments that have a relaxed fit, wherein measurements are acquired exclusively when the requisite pressure is exerted. The utilization of an integrated sensor probe has the capability to enhance the precision of cathode ray tube (CRT) measurements. The FBG pressure sensor was utilized in this particular situation to detect the applied pressure, which served as an indication for initiating the release of pressure. This was done with the purpose of isolating the capillary refill signal. An exponential regression model can be utilized to accommodate the CRT signals, with the degree of fit being associated with the CRT. While prior studies have indicated that the duration and intensity of the blanching pressure can impact the measured capillary refill time (CRT), the ideal pressure and duration for application have yet to be determined. Consequently, the utilization of the probe is expected to be advantageous in ascertaining the most favorable length and intensity of the blanching pressure for the purpose of conducting CRT measurements. No significant correlation was observed between the pressure applied during blanching and the response time of the capillary refill test (CRT) in the dataset of this study. This finding challenges the assumption made in previous studies regarding the importance of blanching pressure on CRT. However, further investigation is required to have a comprehensive understanding of this relationship. Motion artifacts can significantly affect the quality of the signal, similar to other ways of measuring photoplethysmography (PPG). An accelerometer has been employed by certain researchers for the purpose of detecting motion artifacts. In contrast, the FBG pressure sensor is capable of detecting the initiation of contact as well as any subsequent relative motion between the sensor and the finger. In prospective investigations, it is advisable to calibrate the sensor for skin temperature by employing a thermocouple or another FBG temperature sensor positioned on the surface of the epoxy in direct contact with the skin.

ملخص:

قد يتنبأ معدل ضربات القلب أثناء الراحة وممارسة الرياضة بمخاطر الإصابة بأمراض القلب والأوعية الدموية. تقلب معدل ضربات القلب هو مقياس للاختلاف في الوقت بين كل نبضة قلب يمثل التوازن بين الجهاز العصبي السمبثاوي والباراسمبثاوي وقد يتنبأ بأحداث قلبية وعائية ضائرة. تعد الأنظمة القائمة على المنسوجات فرصة تقنية جذابة يمكن ارتداؤها لأنها يمكن أن توفر مراقبة المعلمات الفسيولوجية الرئيسية بتنسيق مريح وغير مزعج. يتم وصف نظام جديد يعتمد على مجسات استشعار الألياف الضوئية متعددة القنوات المضمنة في غلاف الأنسجة. يقيس النظام الرسم البياني الضوئي (PPG)عند طولين موجيين (٦٦٠ و٨٣٠ نانومتر)، والذي يستخدم بعد ذلك لحساب تشبع الأكسجين .(SpO2)مع التقدم في التكنولوجيا وزيادة الاهتمام التجاري، تم توسيع نطاق أنظمة مراقبة الخدمات الصحية عن بعد. في هذه الورقة، نقدم مراجعة للتكنولوجيا المستقبلية غير الغازية للتشبع المستمر بالأكسجين ومراقبة معدل ضربات القلب، والأجهزة القابلة للارتداء، والإيجابيات والسلبيات التي تركز على الدقة، وسهولة استخدام أجهزة التشخيص التجارية والطبية، والتي أظهرت نتائج واعدة من حيث من الموثوقية والقيمة. تطور تكامل الذكاء الاصطناعي والمراقبة عن بعد القائمة على السحابة لتسهيل معالجة البيانات في الوقت المناسب، وتحسين راحة المريض وضمان أمن البيانات. من أجل تحقيق قياس موثوق دون تعديل موضع الثوب، يتم استخدام أربعة مجسات من الألياف الضوئية البلاستيكية (POF)لزيادة احتمالية الحصول على PPG عالي الجودة بسبب وضع واحد على الأقل من المجسات فوق الدم إناء. ينقل كل مسبار الضوء ويستقبله إلى الجلد لقياس PPG وSpO2.يتمتع هذا المستشعر متعدد القنوات بإمكانية تحقيق مراقبة موثوقة وغير مزعجة ومريحة تعتمد على النسيج لكل من معدل ضربات القلب و SpO2خلال الحياة اليومية.

الكلمات المفتاحية: التكنولوجيا القابلة للارتداء، وأجهزة الاستشعار القابلة للارتداء، ومعدل ضربات القلب، ومراقبة معدل ضربات القلب، والمنسوجات؛ الألياف البصرية البلاستيكية، وتشبع الأكسجين.

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