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Editor-in-Chief

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REVIEW ARTICLE

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EDITORIAL

We care much about medical fields which are closely related to every one of us. Wearable technology plays a vital role in modern medicine. The topic of medical wearable technology is impossible to be missed. Hence, we honorably invited three of our editor board members to write articles for this issue.

Prof. Guozhi Huang from Southern Medical University reviewed the background of national policies for the construction of healthy China, summarized the many shortcomings that currently restricted the improvement of rehabilitation service capabilities, and proposed the implementation path of intelligent rehabilitation where wearables were salient in health monitoring. Dr. Julián Patiño-Ortiz proposed a method with a systemic-transdisciplinary approach for the design of eHealth devices, to satisfy the requirements and needs of all those involved in the use of the device and comply with the regulations established in the different countries. Ruben Dario Vasquez Salazar from New Mexico State University reviewed different mobility aids for people with visual disabilities, for the purpose of obtaining a clear vision on the progress of technology and techniques used for assistance in this population. To increase the ability to detect obstacles, the most common devices correspond to the integration of sensors and electronic components in canes. You will get details in these excellent articles.

What's more, we have articles collected in this issue focusing on medical fields such as dentistry, cardiology, etc. Wishing everyone good health!

Editor-in-chief

Dr. Zhen Cao

Wearable Technology (2021) Volume 2 Issue 1, *pp.* 2–8.
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ORIGINAL RESEARCH ARTICLE

Systematic-interdisciplinary approach to eHealth equipment design

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ABSTRACT

eHealth has improved the performance of multiple health systems worldwide by integrating Information and Communication Technologies (ICTs) into national (structured and coordinated) strategies in the health sector. However, once the foundation is laid for the development and implementation of eHealth solutions, researchers, engineers, doctors and other stakeholders have no single way to develop eHealth solutions. Therefore, a systematic interdisciplinary method is proposed to design electronic health equipment to meet the requirements and needs of all people involved in the use of the equipment, and comply with the laws and regulations of different countries.

On the basis of systematic and interdisciplinary methods, a method is proposed, that is, the collaborative use of different systematic methods allows stakeholders to continue to cooperate and share the experience. Consequently, the method will allow the design of eHealth devices that, regardless of their use, meet the needs of the user, the requirements of the personnel who will use them, the standards and regulations of the country where they are developed, and provide total satisfaction with the device. Finally, the eHealth solution is designed through systematic thinking, through the analysis of needs and needs, and through exploring different perspectives, observation backgrounds, participant participation, discussion and stakeholder consistency, so as to provide a sustainable product that meets all participants.

Keywords: eHealth solutions; methodology; system approach; human factors; interdisciplinary

1. Introduction

There are many methods to design medical equipment[1,2], but they cannot be fully applied to the development of eHealth solutions, because most solutions have a prominent aspect: human factors. However, this does not mean that they cannot serve

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as a basis for developing these solutions. However, to some extent, we must fill the gap between the different needs of medical device methods and eHealth solutions.

To this end, it proposes a systematic way of thinking to supplement these missing spaces and create a method that covers all aspects of equipment design[3]. In addition, the systematic approach allows problems to be analyzed from different perspectives and global perspectives, not just unilateral or even individual.

On the other hand, eHealth gives priority to user-centered layout, but it has been proved that one of the main defects in eHealth solution design is not active and the affinity between users is very low. Therefore, using the system method to design electronic equipment is a feasible choice, because it tends to consider all components of the system and their interactions. In this case, human factors will be the main variable of analysis. Although the research of soft systems was initially carried out on the basis of general system theory, in the past few decades, the research of soft systems has become a very useful tool for analyzing complex problem situations with high human impact[4,5], such as eHealth solution.

The reason for creating a systematic and interdisciplinary approach enables eHealth solutions to meet the needs, requirements, regulations, standards, etc. Of everyone involved in using it. This is achieved through the establishment of a working group in which all participants who have any impact on the use, design and development of equipment will participate in order to explore each variable involved through their experience and understanding of each participant.

2. Background

Ehealth seems to have broken the paradigm of health care and provision of health services, and integrated ICT into the health sector[6,7]. However, due to various circumstances (background, resources, investment, culture, etc.), the impact of this trend is different all over the world. Therefore, each country has developed a strategy to integrate eHealth into its health system to meet its needs and potential[8,10].

However, once the eHealth foundation is established in the health system, the next step is to develop solutions matching these foundations to generate an integrated system of medical monitoring, treatment and care, as well as an information system that can better manage the information in the health system. However, the development of these solutions does not have a clear path like the development of medical devices. Due to different situations and aspects, the same method cannot be used, because one method focuses on the use of medical personnel (medical device method), and the other method must focus on any stakeholders in the health sector, especially patients (eHealth solutions). However, through the systematic method and its difference and comprehensive idea, the method of medical devices has become the initial basis of this medical device solution method, that is, to distinguish the methods of medical devices with the characteristics of medical devices, and finally the systematic method. This difference integral is shown in **Figure 1**.

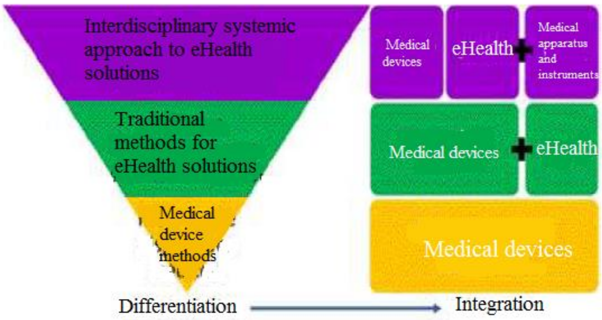

Figure 1. Differentiation-integration process of the interdisciplinary systemic approach to eHealth solutions.

However, some suggestions have been put forward to develop eHealth solutions, among which User-Centered Design (UCD) and technical methods are the most helpful. However, only a few people mentioned the participatory approach in design, the multidisciplinary nature of research, the background of developing solutions, business models, etc., although ultimately all of these should be part of the solution design process.

Therefore, it is suggested to combine all these factors with other factors to form an interdisciplinary systematic method, which can meet both the needs of users and all the research aspects involved in the development of this device.

3. Methods and tools

As systems are becoming increasingly complex, the systemic approach appears on the scene as a tool for interpreting and working with them. The systemic approach proposes a global vision of systems, not as individual entities, but as a whole, given that the sum of their components and the interactions between them generates a result that is superior to that of the individual components. Among the contributions proposed by the systemic approach are the following[5,11,15]:

- Interdisciplinary and multidisciplinary.
- Participate in the process.
- See every element as important.
- Open systems analysis (relationship between system and context).
- Vision of differentiation and integration.
- It focuses on relationships, not objects.
- It allows a large amount of information to be obtained from a small amount of data that synthesizes these data.

There is no doubt that the system method has a comprehensive and multidisciplinary view, but this method cannot be the only tool used in the system, which is why the system method is used. It includes hard, soft, liberated, postmodern methodology and so on.

On the other hand, interdisciplinary is a term. Since the psychologist Jean Piaget put forward it in the 1970s, it tries to take different methods to solve problems and the relationship between subject and object, which not only involves multiple disciplines, but also goes beyond them. In other words, it breaks the boundary of disciplinary knowledge. Because if there is no fixed limitation in reality, why should we analyze it with limited disciplines[16,17].

Interdisciplinary is the pursuit of knowledge beyond disciplines. By integrating disciplines and supplementing with the scientific, experience and practical knowledge of each relevant person, can enrich the solution of any problem[18,19].

The collaborative combination of interdisciplinary and systematic methods enables people to comprehensively explore problems from different angles, with the integral participation of those involved and without thought restrictions. Therefore, for the proposed method, in addition to supporting systematic and non-systematic methods, the advantages of these two concepts will be utilized. For this purpose, a combination of two stages, steps and method models, including technical, human, organizational, commercial and other methods, will be used to produce a postmodern method that allows the creation of e-health devices by meeting technical, human and normative requirements[20].

The procedure for obtaining an interdisciplinary systematic approach is as follows:

- Find the latest ways to create electronic devices.
- Define the method of developing equipment.
- Identify the shortcomings and opportunities of each research method, which will be achieved through an interdisciplinary process, in which participants have different research fields, but have experience in the field of eHealth.
- Define the most important variables for the design of electronic equipment.
- Through the analysis of defects, opportunities and important variables, the best method of treatment equipment design is determined.
- Define the steps and steps of the equipment design method.

A systematic interdisciplinary design method is proposed.

4. Analysis of electronic equipment development methods

Then, we review recent articles published on search engines, such as Scopus, ScienceDirect, Springer link, Google Scholar and IEEE Xplore, and describe the methods used to identify the main development methods used and the main opportunity windows for improvement. **Table 1** shows the analysis of the methods of some electronic devices currently developed.

Table 1. Electronic equipment and its development method

Author/year	Solution suggestions	Main methodological methods
(Tariq. Tanwani and Farooq, 2009)[21]]	Remote patient geti6n	Human approach
(Van Wilson. Wentzel and Van Gemert-Pijnen, 2013)[22]	Intervention measures	Participatory and multidisciplinary method
(Celik et al., 2017)[23]	Mobile ECG	Technological approach
(Verhees, Van Kuijk and Simonse, 2018)[24]	Point-of-care testing through eHealth	Business model
(Almeida. Almeida and Figueiredo-Braga, 2018)[25]	Mobile solutions for depression	Multidisciplinary approach
(Sousa et al., 2018)[26]	Platform to support the care and assistance of older adults	Participatory approach
(Monteiro et al., 2019)[27]	Cloud-based electronic health system	Technological approach
(Shanin et al., 2018)[28]	Using the Internet of things to monitor patients	Technological approach
(Shivakumar, Arora and Mani, 2018)[1]	Universal electrochemical reader	System method
(Monton et al., 2018)[29]	Integrated wearable sensor	Technological approach
(Shokrekhodaei et al., 2018)[30]	Heart rate monitor	Technological approach
(García et al., 2018)[31]	Stroke detection application	Technological approach
(Celesti et al., 2019)[32]	Cloud computing system	Technological approach
(Bedson et al., 2019)[2]	Pain monitoring application	Human approach
(Vossebeld et al., 2019)[33]	Electronic medical record for nurses	Technology acceptance
(Pierleoniet al., 2019)[34]	Atrial fibrillation monitoring	Technological approach
(Vitabile et al., 2019)[3]	Remote processing and analysis of clinical data for health care purposes	Technological approach
(Rihana, 2019)[4]	Vital signs monitoring	Technology and human methods
(Domingues et al., 2019)[35]	Remote gait analyzer	Technological approach
(Kildea et al., 2019)[5]	Person-centered patient portal	Participatory approach

From the research done, it is possible to observe the trend of technology and human methods, but not combined, but go one way or another. In fact, in this review, only one device is developed under the system method, just like under the main development framework.

It is worth mentioning that most revised publications with a major human focus have adopted a participatory approach in their design to give priority to the availability of solutions. Unlike technical method solutions, the technology or materials used are dominant.

However, this does not mean that there is no combination of methodological methods. The most popular one is the combination of technical methods and human methods. Although this is great progress, it at least integrates the background, the current and future interrelationship of equipment, interdisciplinary and systematic global vision.

The information obtained from this analysis shows that some of the methods used in implementing these e-health solutions have opportunities and shortcomings. Therefore, a method can be developed, including the most commonly used methods and the promoted system vision.

5. Development method

Before creating a method, you need to determine which variables will affect the creation of eHealth devices. The following variables are considered when developing methods[10,36,38].

- Human factor
- Technical factor
- Economic factor
- Cultural factor
- Normative
- Context
- Use

Once the variables that make up the eHealth solution and the methods of other authors to develop eHealth solutions[39,44] are determined, it is possible to propose an interdisciplinary system approach that allows the development of these solutions. By comparing the different steps, they can be divided into six stages:

- Problem description
- Diagnosis
- Design
- File
- Implementation
- Operation and maintenance

From these steps, it can be seen that these activities will help to develop eHealth solutions in a systematic and interdisciplinary way in order to benefit from them. **Table 2** lists the steps and activities for each phase.

The proposed method involves all variables of the eHealth solution, as well as systematic and interdisciplinary technologies and some method steps, in order to find a sustainable solution that meets all the requirements of stakeholders.

6. Conclusions

The proposed approach allows the development of eHealth solutions, taking into account all those involved in the use and development of eHealth solutions. Similarly, when establishing the maintenance and permanence phases, it stipulates that the solutions will be continuously monitored, evaluated and innovated. In addition, through the analysis of various existing solutions, the necessary processes or activities for developing these solutions can be determined, and each specific method of comparing solutions can be supplemented. Finally, using tools such as systematic and interdisciplinary approaches, a more comprehensive view of the solution can be obtained by integrating the different views of all parties concerned, but the method still has room for improvement and then evolved into a method, with the aim that each country can develop its own customized method according to its specific needs.

Table 2. Develop eHealth solutions with a systematic interdisciplinary approach

Problem description	Diagnosis	Design	Documentation	Implementation	Maintenance and permanence
Define the problem	Determine the status quo	Idealized model	Record the process of solving the problem	Manufacturing final products	Monitoring and evaluation index
Determine user needs	Determine context	Brainstorming (from practical and theoretical experts)	Document the policies followed and possible changes, if necessary	Implement the final product	Maintain
	Identify resources	Model elaboration	Record the development process of prototype and final product	Define solution evaluation metrics	Implementation feedback (iterative process)
	Determine the specifications and strategies to be followed by the equipment	Choose the best choice			Final product innovation (iterative process)
	Define participation	Prototype development			

Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL RESEARCH ARTICLE

Design of a portable low-power wearable heart rate and blood oxygen monitoring system

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ABSTRACT

Heart rate, blood oxygen and body temperature are all important physiological information of human body, and designing a small and portable system measurement device will have a large social and clinical economic benefit. An attempt was made to design a portable monitoring device with STM32F103C8T6 as the controller. The heart rate, blood oxygen and body temperature data are collected by MAX30102 and GYMCU90615 modules and the data are sent to an Android smart phone via Bluetooth module for analysis and display, realizing an Android-based heart rate, blood oxygen and body temperature monitoring system. The system has been tested and verified to be stable and reliable.

Keywords: heart rate and blood oxygen detection; body temperature detection; STM32F103C8T6; Android; Bluetooth communication

1. Introduction

Heart rate and blood oxygen saturation are important physiological indicators of the human body[1], reflecting the health status of the body. With the development of information technology, the popularity of smart health wearing devices has increased dramatically[2,3]. Xue et al. designed a wearable blood oxygen saturation monitoring device based on Bluetooth low-power technology, which can continuously detect human blood oxygen saturation and pulse rate[4] with the characteristics of low power consumption and wearable, but the detection accuracy of the device is affected when the output blood oxygen saturation of the simulator is lower than 75%. Zhang et al. investigated the heart rate detection method for existing wearable devices and found that the human heart rate varied greatly under different activity states, but no corresponding App program was given for real-time detection[5]. Xu et al. introduced a blood oxygen analog acquisition circuit based on TI’s AFE4400 integrated chip. Their study mainly simplified the circuit design, reduced system power consumption and circuit size, and improved the portability of the hardware, but slightly lacked in the development of the whole system network operation[6]. With the development of network cloud platform technology, some products with the function of detecting human physiological parameters are also developing in the direction of wearable and network real-time monitoring. For

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example, Xiaomi's wearable product Xiaomi Bracelet can provide highly accurate heart rate and sleep quality monitoring; the low-cost finger clip device produced by some domestic manufacturers can detect blood oxygen saturation and heart rate, and display data through OLED screen.

The Android-based heart rate, blood oxygen and temperature monitoring system designed by the author has the features of portability, low power consumption and wireless transmission. The system consists of two parts: hardware side and software side. The hardware side consists of sensor module, Bluetooth communication module, STM32 core circuit and power regulator circuit. The sensor module consists of MAX30102 heart rate and blood oxygen module and GY-MCU90615 infrared temperature module, which sends the collected data to the Android terminal through Bluetooth module, parses the data and displays it on the interface. The specific system design is shown in **Figure 1**.

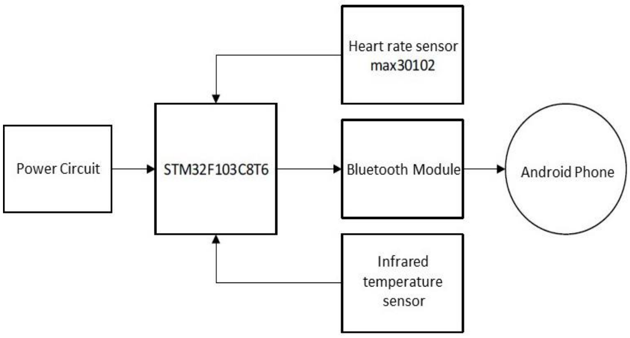


Figure 1. System design framework.

The finished device can help users to measure their body's oxygen saturation, heart rate and other physiological indicators more accurately anytime and anywhere, so as to better grasp their physical condition. From medical analysis, two physiological indicators, blood oxygen saturation and heart rate, are important data for hospital diagnosis and treatment, blood oxygen saturation of 95 and above is normal, and heart rate between 60 and 100 per minute is normal. When the user's measurement results do not meet the above two indicators several times in different time periods, it indicates that there are physical abnormalities, and it is recommended to consult a doctor for detailed investigation.

2. Detection principle

2.1. Heart rate oximetry principle

As the most common means of monitoring measurement, the optical volumetric method is simple, easy to wear, and highly reliable. The basic principle is to use the difference in light transmission generated by human tissue during vascular pulsation for heart rate and oxygen saturation measurement, and the sensor used consists of two parts: A light source and a photoelectric transducer[7,8], which is fixed to the patient's finger, wrist, or earlobe by a strap or clip. The light source is generally a light-emitting diode with specific wavelengths selective for oxyhemoglobin (HbO_2) and hemoglobin (Hb) in arterial blood (generally red light near 660 nm and infrared light near 940 nm are chosen)[9]. When the light beam passes through the human peripheral vasculature, the light transmission is changed due to the change in blood volume caused by the pulsation of the artery, and the light reflected by the human tissue is received by the photoconverter, transformed into an electrical signal and amplified and output. Since the pulse is a signal that changes periodically with the beating of the heart, the arterial blood volume also changes periodically, so the change period of the electrical signal of the photoelectric converter is the pulse rate. Meanwhile, according to the definition of blood oxygen saturation (SaO_2), it is expressed as:

$$\mathrm{SaO_2} = \frac{\mathrm{C_{HbO_2}}}{\mathrm{C_{HbO_2}} + \mathrm{C_{Hb}}} \times 100\% \tag{1}$$

Figure 2 shows the degree of absorption of different frequencies of light by oxyhemoglobin (HbO_2) and hemoglobin (Hb).

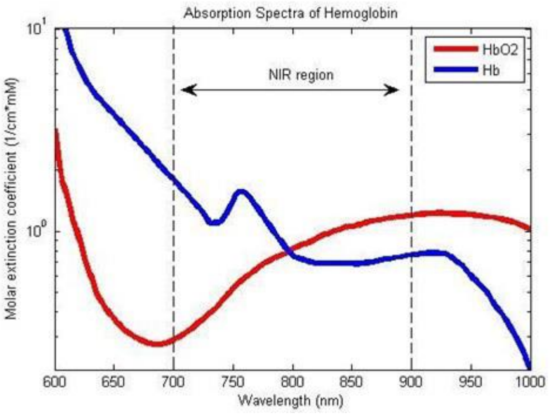


Figure 2. Absorption spectra of HbO_2 and Hb.

2.2. Body temperature detection principle

Infrared temperature measurement is widely used in non-contact temperature measurement equipment[10]. And its principle is to convert the infrared radiation energy emitted by the object into an electrical signal, the magnitude of the infrared radiation energy corresponds to the object's own temperature, and the temperature of the measured body is determined, according to the value of the transformed electrical signal.

3. Hardware system design

3.1. Signal acquisition module

As shown in **Figure 3(a)**, the MAX30102 from Maxim is a high-sensitivity blood oxygen and heart rate biosensor[11]. It integrates LED and driver, light sensing and AD conversion, ambient light interference cancellation and digital filtering parts, leaving only a digital interface, which greatly reduces the design burden of developers.

As shown in **Figure 3(b)**, GY-MCU90615 is a low-cost infrared temperature module with the advantages of low power consumption and small size. Its working principle is to read infrared temperature data by microcontroller and output by serial communication. The circuit connection of the acquisition module is shown in **Figure 4.**

(a) (b)

Figure 3. Blood oxygen heart rate acquisition module, temperature measurement module.

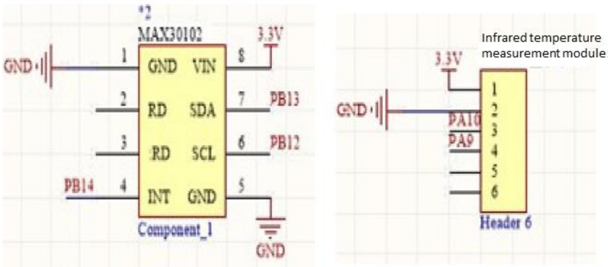


Figure 4. Acquisition module circuit connection.

3.2. Bluetooth module

HC-05 is a high-performance master-slave Bluetooth module can be used directly as a serial port. The physical and circuit connections are shown in **Figure 5**.

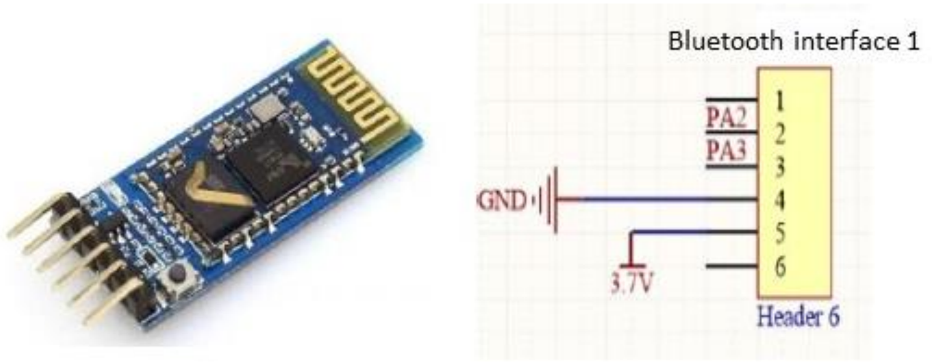


Figure 5. Bluetooth module and circuit connection.

3.3. Power circuit

In the subsequent circuit design, considering the voltage of the supply battery is around 3.7 V, the TPS7333 chip is chosen to regulate the voltage, which is stable within 0.3–0.4 V. The power supply circuit is shown in **Figure 6**.

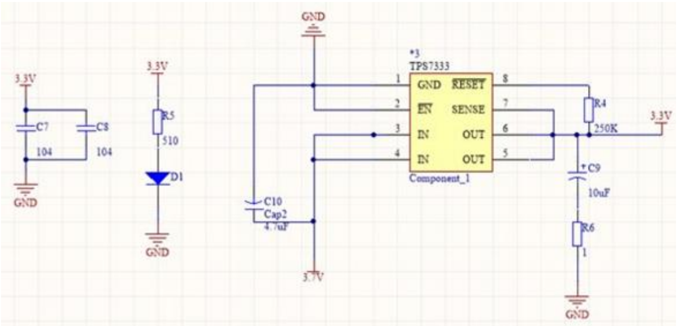


Figure 6. Power circuit.

3.4. Main control chip circuit

The STM32 core circuitry consists of four main parts: (1) reset circuit, (2) crystal circuit, (3) serial port download, and (4) I/O port.

The STM32 is externally connected to two crystals to provide a clock source for its internal system. An 8 M high-speed external clock (HSE) provides the system with a more accurate master frequency; the other is a 32.768 M low-speed external clock (LSE), which is used to provide accurate clock functions. The specific schematic of the system core board is shown in **Figure 7**.

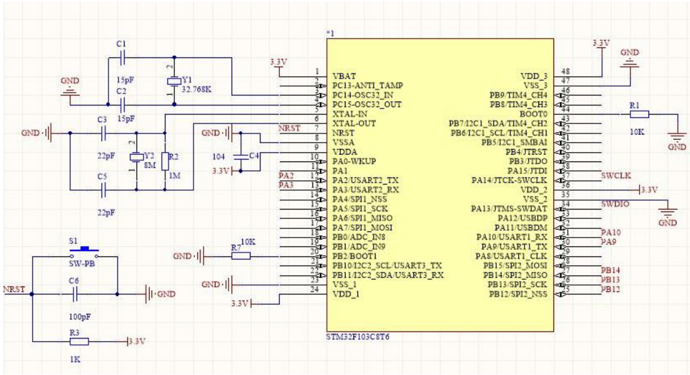


Figure 7. System core circuit.

4. Software development and algorithms

4.1. Communication Protocol

The communication protocol is the main factor that affects the stability of the system[12]. The author’s design requires two serial ports, USART1 and USART2, one interrupt port, and two I^{2}C analog ports for the lower computer side. Among them, the USART1 serial port is connected to the infrared temperature measurement module and the USART2 serial port is connected to the Bluetooth module.

The MAX30102 module uses the I^{2}C communication protocol, and for stability, the software emulation of I^{2}C is used; from **Figure 5**, the USART2 function pins PA2 (TXD) and PA3 (RXD) are used as the communication interface between the lower and upper computers, with a baud rate of 9,600 bps. The GY-MCU90615 module communicates with the STM32 through the USRAT1 serial port. The number of fixed packets is 9 frames and the protocol is as follows.

(1) Frame header: Byte0 and Byte1 fixed frame header 0x5A. (2) Data bits: Byte2 indicates the data type of this frame. Byte3 indicates the amount of data (2 groups of 4 bytes of data for one parameter). Byte4 indicates the high 8 bits of the target data. Byte5 indicates the low 8 bits of the target data. Byte6 indicates the high 8 bits of the ambient temperature data. Byte7 indicates the low 8 bits of the ambient temperature data. (3) End of frame: Byte8 in the range 0x00-0xFF is the checksum (the sum of the previous data accumulation, only the lower 8 bits are kept).

The frame determines the correctness of the data header, frame tail and frame length, and the required data is extracted from the correct data bits of the frame set and parsed to complete the data conversion.

4.2. Lower computer firmware development

The main function integrates the heart rate and blood oxygen acquisition and infrared temperature measurement programs. The main logic is to read the serial number firstly, determine the data sent by the serial port can correctly parse, and then send a query instruction; after that, the interrupt trigger of heart rate blood oxygen detection was checked. If the interrupt was triggered, the heart rate blood oxygen module could work normally. Then, the red light and infrared light were read, and 100 groups were read each time and stored in an array. After reading, AD conversion was performed. Since the sum of the read values is less than 500 groups in the initial stage, the data cannot be displayed for about 5 s. After that, the module works normally and performs mean filtering on the 500 groups of collected data. The heart rate and blood oxygen values collected are judged to be normal, and the collected values are confirmed to be valid before the group frames are sent. After the sending is completed, the data shifting of the array is performed, in which the previous data are discarded and only 500 data in the array are saved forever.

The infrared temperature measurement module works by means of serial communication. The principle is that the module sends the command 0xa5+0x15+0xBA to the device, and the device then returns a piece of data, of which the valid data can be taken. In this program, the command query method is used, which means that the command needs to be sent each time for the sensor to return the value.

4.3. Brief description of the algorithm

The algorithm for heart rate and blood oxygen detection is ported from the official Maxim library. The main functions used in the program are:

voidmaxim_heart_rate_and_oxygen_saturation

$$\begin{aligned}(\text{uint32t} * \text{pun\_ir\_buffer, int32\_t n\_ir\_buf}&\\ &- \text{fer\_length, uint32\_t}\\ &* \text{pun\_red\_buffer, int32\_t}\\ &* \text{pn\_spo2, int8\_t}\\ &* \text{pch\_spo2\_valid, int32\_t}\\ &* \text{pn\_heart\_rate, int8\_t}\\ &* \text{pch\_hr\_valid})\end{aligned}$$

Put the read parameters of red light and IR light into the array and fill the array names of red light and IR light into the corresponding array parameter names. The parameters **pn_heart_rate* and **pn_spo2* are variables for the output results. **pn_heart_rate* outputs the heart rate and **pn_spo2* outputs the blood oxygen concentration. **pch_spo2_valid* and **pch_hr_valid* are used to determine the validity of the acquired heart rate and blood oxygen, if it is 1, it means the corresponding parameters acquired are valid; if it is 0, it means the acquired values have too much error and are judged as invalid. The invalid value is indicated by -999, and only the valid value is output.

4.4. Upper computer software development

The upper computer APP is written in Android Studio, mainly divided into four parts: Bluetooth connection, data processing, UI refresh, and curve plotting. The specific software main flow is shown in **Figure 8**.

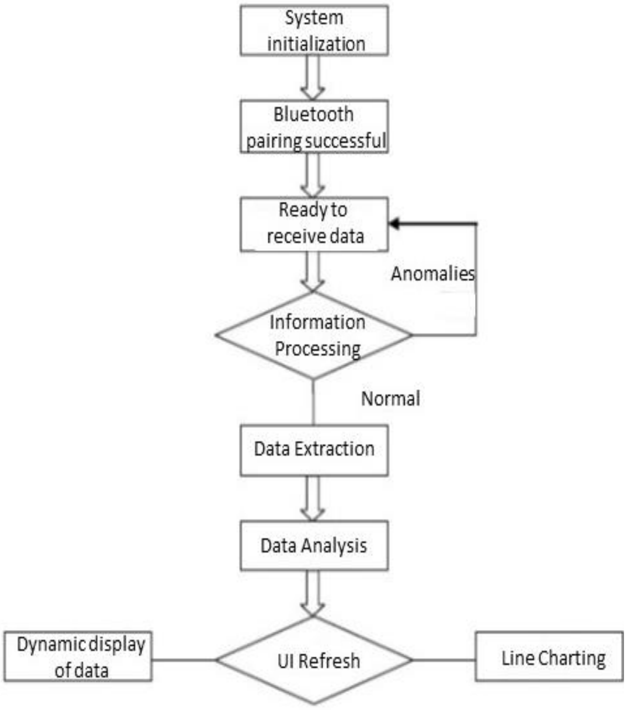


Figure 8. Software master process.

The Bluetooth connection requires that the phone has been paired with the Bluetooth module. The data processing is mainly to parse the frame data, and the UI refresh is done by a handler mechanism, which determines which part of the UI to refresh based on the msg parameter sent by sendHandlerMessage. After getting the parsed data, the github component is called to draw the curve.

As shown in **Figure 9**, the APP has a main interface (a) and two types of sub-pages for all monitoring (b) and single monitoring (c), which are used to display the current value of the signal and its change curve.

Paired Devices: HC-05

Heart rate 63 BPM

Blood oxygen 100 %

Body temperature 26.79 ℃

Heart rate : 55 BPM

Figure 9. Android UI and functions.

5. Test results

As shown in **Figure 10**, the test conditions were indoor, 26 °C, and the test subjects were in normal physical condition (not strenuously exercising). The main reason for choosing to collect the human static data indoors[13] is that there are fewer disturbing factors such as noise and light, which are more conducive to extracting valid data.

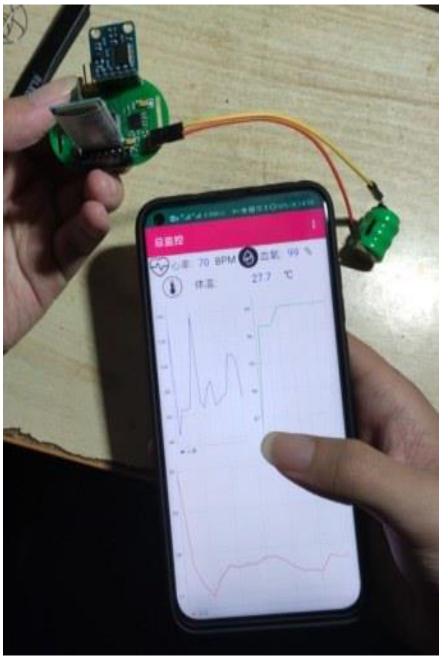


Figure 10. System testing.

When the battery of the device is powered on, the LED of the Bluetooth module is flashing, and the Android APP is opened for testing, when the flashing frequency of the LED of the Bluetooth module is reduced, it indicates that the communication between the upper computer and the lower computer is successful. The heart rate, temperature and blood oxygen concentration values collected by the lower computer are displayed in real time on the Android terminal, and are shown in the form of a line graph. Since the system has received less than 500 sets of data in the first 5 s, it cannot be displayed.

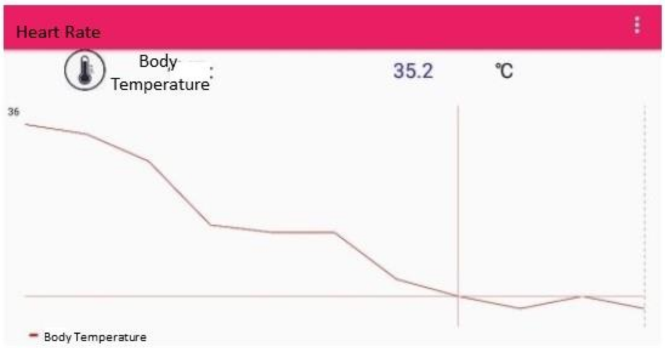
Figure 11–13 show the screenshots of each test interface, in the case of good contact between the device and the human body, the collection of data is normal and relatively stable. By comparing the data of the same period with the more mature portable heart rate and blood oxygen detection products on the market, such as Xiaomi bracelets, it meets the expected results.

Heart rate : 62 BPM

Figure 11. Heart rate interface.

Blood Oxygen : 98 %

Figure 12. Oximetry interface.



Body Temperature : 35.2 ℃

Figure 13. Body temperature interface.

6. Conclusions

The design of heart rate, blood oxygen and temperature monitoring system based on Android system is briefly introduced, aiming to provide an intelligent monitoring device for home and other environments. After testing, the system can detect the signals more accurately and display the data and change curve in real time on the Android terminal, with the features of low cost, easy to carry[14], simple operation, and wireless transmission.

Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL RESEARCH ARTICLE

Practical needs of oral prosthodontics in the field of health

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ABSTRACT

Reason: Teeth, related to chewing, aesthetics and vocal function, are an essential element. Therefore, the absence of teeth is considered to lead to the deterioration of oral health. **Objective:** To determine the actual needs of oral restoration in the Northern Health District of Camaguey city. **Methods:** A cross-sectional descriptive study was conducted on the population in the Northern Health District of Camaguey city from October 2013 to April 2015. The study included 574 men and women aged 18 and over. **Results:** Female patients over 60 years old were dominant. Of the 574 people examined, 401 were determined to need artificial rehabilitation, and tooth loss was the main reason. People over the age of 60 have the greatest actual demand for prosthetics. With regard to gender, it was noted that women needed some prosthetic treatment because it was higher than men. **Conclusion:** The actual demand for oral restoration in female patients over 60 years old is widespread, and the main reason is the loss of teeth.

Keywords: dental papers; oral health; quality of life; aged; describe epidemiology

1. Introduction

Oral health includes the components of teeth, but it is also related to the whole oral dynamic complex. At present, it is recognized that oral diseases have a significant impact on the biopsychosocial field of patients. In terms of pain, deterioration of function and decline in quality of life, as well as social and economic impacts[1].

According to Quez et al.[2], tooth is related to chewing, aesthetics and vocal function and is an essential element, so the absence of teeth is considered to lead to health deterioration. Fuentes and others[3] believe that the deterioration of oral health will not only bring biological problems, but also affect people's psychology. Some patients believe that tooth loss will lead to depression, while for others, this is an inevitable reality and can be attributed to natural causes.

Edentulosis is an oral health condition that corresponds to tooth loss, which is divided into partial and total by Bargas et al.[4] (which means that the causes of edentulosis may vary depending on caries and periodontal disease). Hernández Y et al.[5] believe that the partial or total loss of teeth must be solved through restorative rehabilitation. Traditional dental restoration has long been the main means of rehabilitation treatment because of its adaptability,

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functionality, biocompatibility and economy.

Obviously, for Navarro and others, dental restoration is an option to restore the health of missing teeth, but in turn, it needs maintenance and care to perform its built function. They provide an aesthetic and functional solution to solve tooth loss and resulting defects, so as to improve the quality of life of the wearer.

Romero and others cited seven studies that revealed that edentulism is a common oral condition in adults. Therefore, a considerable number of people wear dentures, resulting in varying degrees of disability or disability, which can be improved only by partial rehabilitation.

Regardless of the cause of tooth loss, restorative stomatology will provide treatment for patients with any degree of complexity by restoring the aesthetic function and harmony of the oral dynamic system. Therefore, it was suggested to determine the actual needs of the population over 18 years old for oral diseases in the Northern Health District of camagui city.

2. Method

From October 2013 to April 2015, a cross-sectional descriptive study was conducted on the population of the Northern Health District of Muni cipio Camaguey. The world consists of 574 people over the age of 18 who agreed to participate in the study voluntarily, but patients who need fixed prostheses are excluded due to the complexity of clinical and laboratory.

In order to collect information, each family used a form, using observation techniques, through questioning and oral examination. The researchers examined the subjects with natural light and a sublingual press. If a person is not at his residence during the visit, he/she will come back twice so that he/she can apply for the form. Surgery was performed as a variable of interest: Age, gender, actual demand for oral prostheses and reasons for demand. Age: According to the age of completion, the following groups used the scale: 18–29, 30–39, 40–49, 50–59, 60 and above. Gender: Described according to biological conditions.

Determine the patients with partial or total missing teeth or both as the actual needs of oral restoration, define the parameters of actual needs and their causes, and determine through expert consensus. The eight criteria considered by Delphy method are: Some or all of the prostheses in use do not meet the biomechanical, aesthetic and functional requirements. Prosthetics that have been used for more than five years. Partial loss of denture restoration is allowed. Clinical examination showed that due to the existence of extensive, complex and profound cavities, they could not be repaired by conservative methods, and the teeth of patients with residual root and periodontal disease could not be treated with periodontal therapy.

After collecting the data, one of the record tables was revised, and a result processing and analysis database was established in SPSS 15.0 for Windows program. Summary measurements were used for qualitative variables (absolute, relative, ratio, ratio, index) and quantitative variables (absolute, relative, average, average Na, fashion). This information is displayed in tables statistics through Microsoft Word and Excel for Windows XP text editor and prepared together with the final report. Bioethics: It abides by the principles of medical ethics through the individual and dual informed consent of each patient.

3. Results

The age and gender distribution of patients were analyzed. Of the 574 subjects, patients over 60 years old accounted for 30.8% and women accounted for 58.2% **(Table 1)**.

Table 1. Patients who need prosthodontics according to age and gender. North Health District, camague. October 2013 to April 2015

Age group	Female		Male		Total	
	No.	%	No.	%	No.	%
18–29	61	10.6	43	7.5	104	18.2
30–39	49	8.5	35	6.1	84	14.6
40–49	57	9.9	50	8.7	107	18.6
50–59	59	10.3	43	7.5	102	17.8
60 and above	108	18.8	69	12.0	177	30.8
Total	334	58.2	240	41.8	574	100

By assessing the actual demand for dental prostheses and their causes in the whole subject population, it was concluded that of the 574 patients who met the standard, 69.9% did need dental prostheses and 82.2% were mainly due to tooth loss **(Table 2)**.

Table 2. According to the actual needs of oral restoration

Reason	No.	%
No prosthetics are required	173	30.1
Need a prosthetic	401	69.9
(a) Tooth loss	330	82.3*
(b) Insufficient deformation	119	29.7*
(c) Prosthetics over 5 years old	112	25.4*

*The relative frequency came from 401 patients who actually needed prosthetics

The distribution of patients who actually need prosthetics according to age group was studied; The elderly over 60 years old most need artificial rehabilitation, accounting for 25.4% **(Table 3)**.

Table 3. Actual need for prosthodontics by age

Age group	Need a prosthetic		No prosthetics are required		Total	
	No.	%	No.	%	No.	%
18–29	28	4.9	76	13.2	104	18.2
30–39	53	9.2	31	5.4	84	14.6
40–49	89	15.5	18	3.1	107	18.6
50–59	85	14.8	17	2.9	102	17.8
60 and above	146	25.4	31	5.4	177	30.8
Total	401	69.9	173	30.1	574	100

The distribution of patients who actually need oral repair by gender shows that women account for 42.3% compared with men who need some kind of repair and rehabilitation **(Table 4)**.

Table 4. According to the actual needs of oral restoration according to gender

Gender	Need a prosthetic		No prosthetics are required		Total	
	No.	%	No.	%	No.	%
Male	158	27.6	82	14.9	240	41.8
Female	243	42.3	91	15.9	334	58.2
Total	401	69.9	173	30.1	574	100

It is hoped that most of the people under review belong to the elderly, because the increasing proportion of people aged 60 and over (i.e. Population aging) is a phenomenon involving the vast majority of developed or non-developed countries. Abascal et al.[9] and Leyva et al.[10] consider this demographic situation as a fundamental aspect of economic and social planning, including health action, and are known as the aging countries of Latin America and the Caribbean: Barbados, Uruguay and Cuba supported the conclusions of the current study.

In the scientific article "the impact of repair on the quality of life of patients", Lages Ugarte M et al.[11] mentioned the greater advantages of women's repair needs and explained how she adapted to the demographic situation of the Cuban population, which is the legitimacy of the statement that women are dominant but less than 100% in the study of Leyva et al.[9] and Segura et al[12]. Reported figures ranging from 52.4% to 53.1%.

When analyzing the reasons for the demand for oral restoration in the test population, it is found that the root cause of the problem is the lack of natural teeth. Molina et al.[13] believe that one of the main causes of tooth loss in the middle-aged and elderly may be dental caries and periodic diseases, which is the most common problem in oral activities. It also emphasizes the need for early diagnosis and treatment.

Carpio et al.[14] made the scientific community reflect on the problem of tooth loss, and pointed out that if you want to maintain oral health throughout the individual's life cycle, you must replace the missing teeth as soon as possible. If there are some residues, their preservation is very useful for the success of rehabilitation treatment.

Hernández et al.[15] found that in any population, many couples or completely toothless people did not undergo any type of restorative rehabilitation, and the number of lost teeth increased with age. It was reported that 20 teeth were lost in people over the age of 60, as was still the case in Holmén et al.[16]

Divaris et al.[17] emphasize the need for effective prosthetic rehabilitation, not only because the lost function is restored, but also because with the increase of tooth removal time, the reabsorption of the flange is ongoing, and then the supporting surface of the prosthesis will be damaged in the future.

These data may be due to the high incidence of different types of tooth loss without timely resolution. Sometimes, people in these age groups don't like to see stomatologists to replace some missing teeth. They don't think it's very important, or they think it's a unique and constant change for the elderly. Therefore, it's necessary to reflect and strengthen the prevention and health education for the long-lived.

The study cited by Neto et al.[18] shows that in the studied population, especially the elderly, most of them need at least one complete denture. Xavier IA et al.[19] believe that in general, the need for such treatment has had a significant impact on many people around the world, and this assumption is worth it.

Barbosa et al.[20] confirmed in a survey conducted in Araraquara, Brazil, in 2011 that 80% of the adult non institutional elderly who actually need to submit papers need prosthetics, while the proportion of institutional elderly people who need prosthetics ranges from 78.1% to 80.28%. It can be seen that these data are similar to the current study and reflect the advantages of people over the age of 60 (82.5% of the actual needs of this group), but they are different from the data found by Iturriaga et al.[21] In assessing the actual needs of oral prostheses in the age group of 35 to 59.

A study conducted by Contreras et al[22]. In Pinar del Rio on the behavior of subplatelet stomatitis in people over the age of 15 found that under the same conditions (59.1% and 40.9% of the total cases), even at the population level, women wearing dentures were superior to men, indicating that women's various types of tooth loss had higher antecedents. It is generally believed that in some countries, the prevalence of edentulosis is higher in women than in men.[23]

According to a study on the health of Mayo res people conducted by Chaves de Mendonça et al. In

Brazil on the 23rd, the rate of tooth loss in women increased by 65% compared with men, and these possibilities increased by about 5% after the age of 65. The above results are consistent with the study of Vázquez et al.[24] in Mexico, Pérez ML et al.[25] in Spain, López A et al.[26] in Colombia. Female tooth loss is dominant.

Tamayo et al.[27] pointed out that Cuban women have a higher proportion of tooth loss, and there are good reasons to believe that women pay great attention to aesthetics and turn more to zoology services. He also quoted Winkher, who believes that women have a tendency to die early and is more interested in rehabilitation.

Hernández et al.[15] found no significant statistical difference between age group or gender and caries index (CPOD) in their clinical evaluation of subjects' dental condition. However, compared with men, the average el (CPOD) of missing components (15.06 missing teeth in women and 12.80 missing teeth in men) in the female group is higher than that in men, which makes it reasonable to believe that women are more likely to receive prosthetic rehabilitation services in stomatology.

4. Conclusions

Among female patients over the age of 60, the real demand for oral repair is widespread, mainly due to the loss of teeth.

Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL RESEARCH ARTICLE

NB-IoT-based health monitoring system for COVID-19

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ABSTRACT

To address the problems of complex networking, low transmission rate and poor reliability of current health monitoring systems using Wi-Fi and Bluetooth transmission, an NB-IoT-based health monitoring system for COVID-19 is proposed. The system uses the STM32F103RET6 as the main controller, and the smart wearable device uses the NB-IoT information transmission method to transmit data to the software client platform with the OneNET cloud platform to realize the remote monitoring of key medical parameters of COVID-19. The test results show that the system is stable and reliable in data transmission, reducing the development cost and power consumption of existing health monitoring terminals, and has certain practical value and market prospects.

Keywords: COVID-19; NB-IoT (narrow band Internet of things); smart wearable devices; health monitoring; OneNET platform

1. Introduction

Health monitoring systems based on wearable smart devices help healthcare workers to prevent and diagnose diseases based on relevant medical data and take timely measures, which can effectively maintain people's health and life safety. With the advent of the 5G era and the continued maturity of the Internet of Things infrastructure, wearable smart devices are entering a new phase of development. Especially during the COVID-19 epidemic, the demand for monitoring key medical parameters such as body temperature and cough conditions as well as GPS positioning has increased significantly, and there is a new demand for the application of wearable devices.

At present, wearable smart medical devices are mainly used in the elderly and children's groups, and most of them use Wi-Fi or Bluetooth wireless transmission technology, such as fall detection systems for the elderly based on wearable sensors[1], intelligent listening devices for paediatric diseases[2] and so on. Due to the high pricing of the products, and the inability of Wi-Fi or Bluetooth wireless transmission technology to meet the business needs of large connection density, low power consumption and high compatibility[3], these devices are difficult to be widely used.

Narrow band internet of things (NB-IoT),

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which is incorporated into the 5G technology standard, focuses on wide-area IoT scenarios, with the characteristics of large connectivity, wide coverage, low cost and low power consumption, and has the advantages of practicality, high reliability and cost-saving when applied to health monitoring systems[4]. As a new space technology for narrowband wireless access, NB-IoT can coexist with existing cellular networks without the need for a new core network, which is conducive to reducing network deployment costs and accelerating deployment rates[5]. Under NB-IoT, smart wearable devices can automatically access the server after successful registration, avoiding the complicated connection configuration operation of Wi-Fi, and greatly improving the networking rate of devices. At the same time, when the population base for epidemic monitoring is large, NB-IoT can effectively solve the problems of power consumption and connection density faced by smart wearable devices.

Therefore, to solve the problems of high cost and low reliability of traditional health monitoring systems, this paper proposes a design of a health monitoring system based on NB−IoT technology for COVID-19. The system integrates wearable sensor technology and NB-IoT communication technology and is designed and developed in the OneNET cloud platform using embedded software and hardware collaborative technology to achieve the monitoring of key medical parameters and remote control of warning lights in the web interface.

2. Demand analysis and overall system design

2.1. Demand analysis

Traditional health monitoring devices that use transmission methods such as Wi-Fi and Bluetooth have complex networking and low reliability, and most connected monitoring devices require independent development of backend servers by developers according to the actual application, increasing the development difficulty and extending the development cycle. In addition, although wearable devices with low latency sensitivity have low data transmission rate requirements, the access of a large number of devices and the processing of data place high demands on the connection density and energy consumption control of the system[6]. According to the performance comparison of the commonly used wireless transmission technology in **Table 1**, NB-IoT technology has the characteristics of simple networking, high connection density, high reliability and low power consumption. It can effectively compensate for the shortcomings of the existing health monitoring system using Wi-Fi and Bluetooth technology in standby time, amount of accessible equipment and security, and can meet the market demand.

Table 1. Performance comparison of common wireless transmission technologies

Comparative content	Networking methods	Single network access node capacity	Transmission distance	Transmission speed /(Mibit.s^{-1})	Reliability	Battery life	Cost/$	Network delay/s
Wi-Fi	Wireless router	Approx. 50	Short	11-54	Low	Few hours	25	<1
Bluetooth	Gateway for Bluetooth mesh	Theoretical approx. 60,000	Short	1	High	Few days	2–5	<1
NB-IoT	Existing cellular networks	Approx.100,000	Long	0.16–0.25	High	Theoretical approx. 10 years/AA batteries	2–3, with a future target of reducing to 1	6–10

The paper adopts NB-IoT data transmission technology for the design of the New Crown Pneumonia Health Monitoring System, making full use of the API interface and standard access protocols provided by the OneNET platform to reduce the development difficulty and shorten the development cycle. The main functions of the system are:

(1) Data acquisition via sensors for cough, heart rate, blood pressure, body temperature, GPS, etc. (2) The collected sensor data are analyzed, and the working state of the warning lamp is controlled by the downlink command. The NB-IoT wireless communication technology is used to send the user's health data to the OneNET cloud platform, and the data are displayed on the client to facilitate users to view. (3) Remote control and health monitoring of warning lights based on the display of client information.

2.2. Overall system design

A COVID-19 health surveillance system was designed based on reference[7]. It consists of four layers: data acquisition layer, communication layer, application service layer and user layer. The overall structure is shown in **Figure 1**.

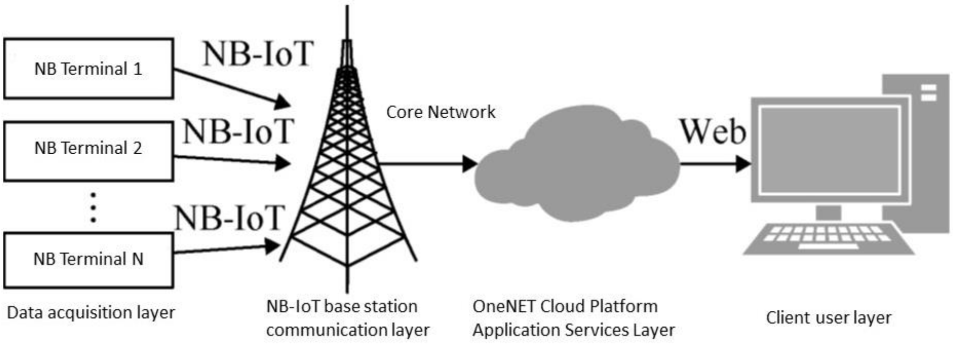


Figure 1. General architecture of the health monitoring system.

From left to right, layer 1 is the data collection layer, which mainly includes the NB terminal consisting of the main controller, health data monitoring module and GPS sensor, warning light, power supply module, NB-IoT communication module and so on. Among them, the health data monitoring module and GPS sensor store the collected data in the controller and send the parsed data to the mobile NB-IoT base station using the NB-IoT module. This layer is the underlying core part of the system.

Layer 2 is the communication layer. The data collected by the data acquisition layer is sent to the mobile NB-IoT base station through the NB IoT communication module, and then transmitted by the base station through the core network to the OneNET cloud platform. This layer is the core of the integration of the Internet of Things and narrowband communication technology.

Layer 3 is the application service layer, responsible for receiving data from NB-IoT base stations and configuring sensor resource parameters to upload the data to the OneNET cloud platform, which stores and analyses the data, eventually realizing the subscription of resources and remote control of terminal actuators.

Layer 4 is the user layer, which extracts and calls the data forwarded by the application service layer and forwards the downlink commands. Managers can remotely control and real-time monitor the health monitoring system through the Web operation interface.

3. System hardware design

The system hardware design mainly refers to the hardware design of the health monitoring terminal node, which is responsible for realizing the functions of the data collection layer. That is, the wearable monitoring equipment is used to realize the location report of the patients, the collection and processing of health information, and the collected data are uploaded to the NB-IOT base station to realize the communication connection of the communication module[8]. The hardware structure is shown in **Figure 2**.

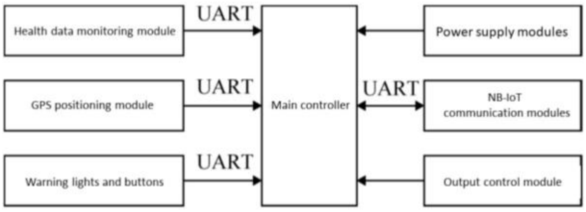


Figure 2. Terminal node hardware architecture design.

The main controller is the STM32F103RET6 microcontroller. The health-monitoring module consists of the ADXL345 3-axis acceleration sensor for determining falls and monitoring coughs, and the Yunkear MKB0908 smart wearer sensor for detecting the wearer’s heart rate, blood pressure and body surface temperature. The ADXL345 sensor detects the wearer’s spatial acceleration to determine their current state of motion. When the wearer reacts by falling or coughing, the sensor will report the monitored body fluctuation data. The main controller uses serial communication to receive data from the health monitoring module and GPS positioning module, sends data to the NB−IoT communication module via another UART, and then uses NB−IoT wireless communication technology to transmit the received data to the IoT cloud platform. The working status of the warning light is determined by the value of the electrical signal output from the output control module[9]. The power supply module uses an AC/DC switching power supply to output the 220 V AC input from the user to 5 V DC to power the various sensors, and the voltage is reduced to 3.3 V by DC/DC to power the main controller[10].

The NB−IoT wireless communication module consists of the M5310-A NB module, SIM card holder, debug serial port, antenna, reset button, LED indicator and a power supply module to provide 5 V operating voltage. The M5310-A is a chip module in an LCC package measuring only 19 mm × 18 mm × 2.2 mm. It has built-in data transmission protocols such as UDP/CoAP and extended AT commands. The M5310-A module has a built-in data transfer protocol such as UDP/CoAP and extended AT commands, and uses a low power consumption technology with current consumption as low as 3 µA in PSM mode. The specific functions of the M5310-A module are shown in **Figure 3.**

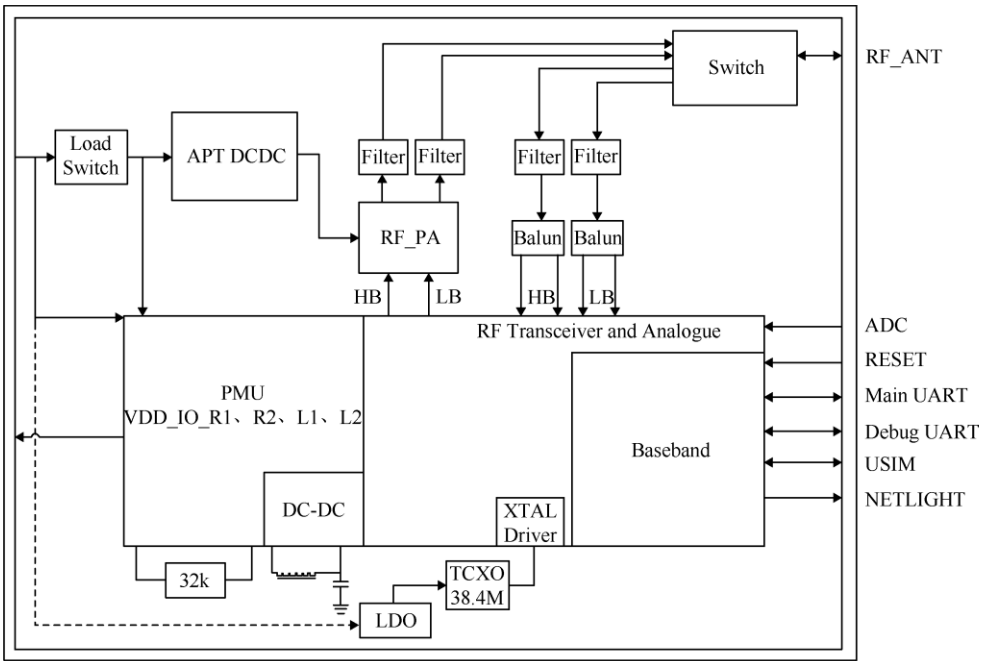


Figure 3. M5310-A module features.

The wireless communication module forwards the sensor data collected and processed by the main controller and the working status of the warning light to the IoT cloud platform via the Internet and receives commands from the user independently. The design of the NB-IoT wireless communication module is shown in **Figure 4**.

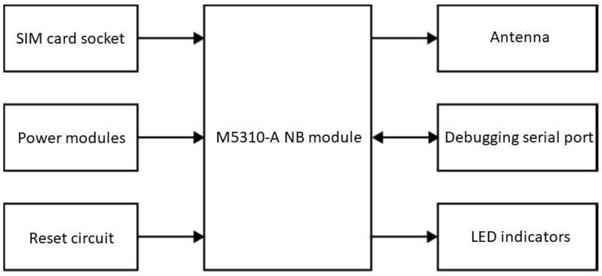


Figure 4. NB-IoT wireless communication modules.

4. System software design

The system software design mainly includes the design of the data communication protocol between the NB terminal and the IoT cloud platform. The communication protocol for accessing the NB base station in the communication layer of the overall system architecture, as well as the software design of the main controller of the NB terminal, the access process of the IoT cloud platform in the application service layer and the client software design in the user layer.

4.1. Data communication protocol design

The system is developed on the OneNET platform by adding corresponding NB-IoT devices and the communication between the NB terminal and the OneNET platform is realized by the LwM2M protocol and CoAP protocol based on NB-IoT[11]. The CoAP protocol, which supports data retransmission and is suitable for low-power scenarios, is used for data transmission in the transport layer.

LwM2M as an application layer protocol defines logical operations such as read, write, execute, subscribe, etc. in the LwM2M Protocol for the identification of sensors and sensor attributes. CoAP is a network-oriented protocol based on the UDP protocol as a transport layer protocol, which is based on REST interactions and can be used to access IoT devices; CoAP abstracts resources according to the IPSO specification and follows the basic UDP protocol message format. Because of the transport unreliability of UDP as a non-connection-oriented protocol, CoAP has a retransmission mechanism and can detect regular redundancies in wireless sensor network nodes, providing a better way to optimize resources.

In addition, as the NB terminal used in this system has a built-in SDK for interaction with the OneNET platform, a UDP connection can be established with a simple AT command. After the NB terminal has successfully acquired the Bootstrap server and returned the LwM2M access server address and port, the terminal device will automatically complete its access to the OneNET platform.

4.2. Terminal node software design

In the NB-IoT data transmission design used in this system, health data is sent from the main controller to the NB-IoT wireless communication module via UART, and then communicated with the mobile NB-IoT base station via CoAP, which is then forwarded to the OneNET cloud platform via the core network[12].

The software design flow of the terminal is shown in **Figure 5**. Initialization operations are carried out automatically after the system is powered up. First is the initialization of the main controller microcontroller. Next is the initialization of the modules, including the NB-IoT communication module and the initialization of each sensor. Afterward, the sensor information is collected, parsed and stored by a timer, and the data is sent to the NB-IoT module, which is then uploaded to the IoT cloud platform.

4.3. IoT cloud platform

In the application service layer, the system uses China Mobile's OneNET IoT platform, a PaaS-level open cloud platform built by China Mobile for IoT technology, for storage and analysis of big data. The platform provides rich terminal access protocols and API interfaces[13], which can effectively reduce the development difficulty of device access and connection, greatly shorten product development and deployment time, and provide a convenient and fast development and deployment solution for smart hardware, smart cities and other IoT scenarios. **Figure 6** shows the OneNET access flow.

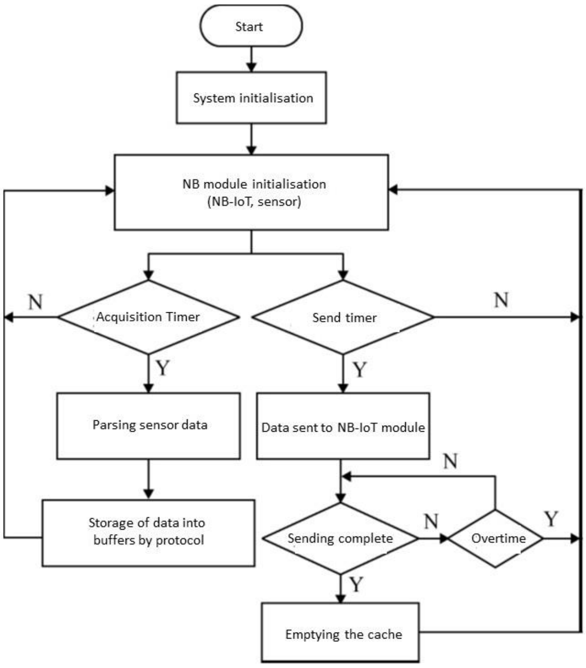


Figure 5. Terminal software design process.

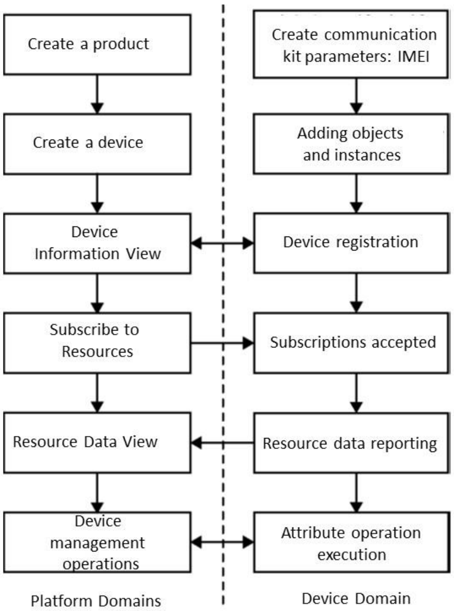


Figure 6. OneNET access process.

4.4. Client software design

The user layer uses a web interface. The client software platform is designed to enable the OneNET platform to interface with IoT devices, to obtain, parse and store data reported to the OneNET cloud platform from terminals through an API interface, and to display the data in the web application. For patients and healthcare professionals, this allows them to have a dedicated operating platform without having to go through the OneNET platform to view data, enhancing the scalability of the system and the ease of operation for users. The flow of the client software platform operation is shown in **Figure 7**.

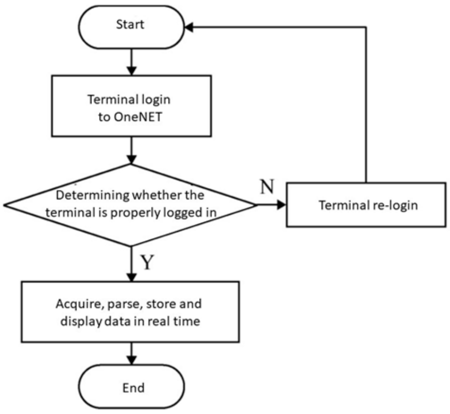


Figure 7. Client software design process.

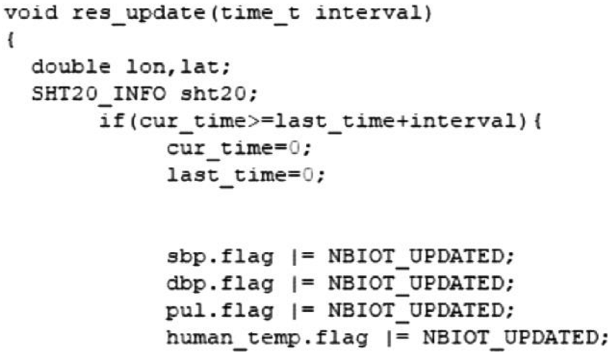
5. System testing and analysis of results

To verify the effectiveness of the system, a wearable NB terminal was placed on the test subject to collect key medical data on COVID-19. After creating a device with the IMEI number of the NB terminal on the OneNET cloud platform, the data was uploaded to the cloud in 100 s intervals. It uses json technology, URL docking device API in OneNET platform and HTTP to push data to client Web interface for data analysis and remote monitoring.

5.1. Data upload and distribution testing

Data upload test

After creating the sensor-related resources and configuring the resource properties, the device carries the corresponding resource list to establish LwM2M communication and the server subscribes to all resources in the device resource list on its own. When the user periodically uploads the sensor value of a resource, the flag property of the resource needs to be set to NBIOT_UPDATED and the program will actively upload the sensor value of the subscribed resource to ONENet at the specified interval[14]. As shown in **Figure 8**, the temperature and humidity sensor values are parsed in the main function and entered into the res_update function, which first sets the status of the temp resource to NBIOT_UPDATED and then receives the temperature and humidity sensor data periodically.

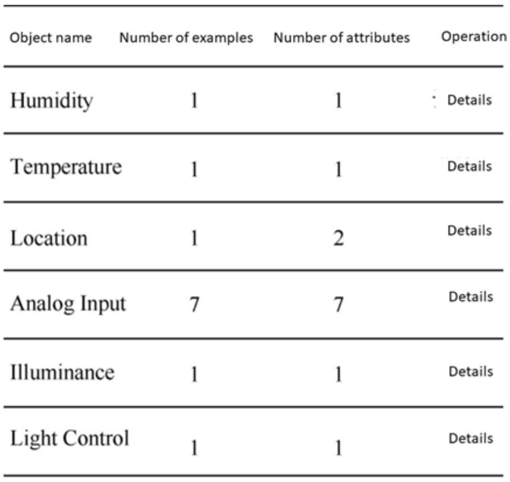


```
void res_update(time_t interval)
{
  double lon,lat;
  SHT20_INFO sht20;
       if(cur_time>=last_time+interval){
              cur_time=0;
              last_time=0;


              sbp.flag |= NBIOT_UPDATED;
              dbp.flag |= NBIOT_UPDATED;
              pul.flag |= NBIOT_UPDATED;
              human_temp.flag |= NBIOT_UPDATED;
```

Figure 8. Key code for data upload to IoT cloud platform.

The test results show that the system is able to meet the functional requirements of the new crown pneumonia health monitoring, with low latency, high reliability and low power consumption for continuous operation using NB-IoT technology in the case of large amounts of medical data uploaded to the cloud. The data presentation of the health monitoring system sensor values on the OneNET platform is shown in **Figure 9**.



Object name	Number of examples	Number of attributes	Operation
Humidity	1	1	Details
Temperature	1	1	Details
Location	1	2	Details
Analog Input	7	7	Details
Illuminance	1	1	Details
Light Control	1	1	Details

Figure 9. Data presentation of health monitoring system sensor values on the OneNET platform.

Data distribution testing

The client sends downlink commands to the OneNET platform and the cloud platform forwards them to the NB terminal. The downlink commands are cached by the NB terminal so that the program can get the downlink control commands directly from the cache, and the write hook function in the resource corresponding to the command will be called automatically after the command is parsed at the device side to complete the operation related to the signalling. **Figure 10** shows the operating status of the Boolean warning light.

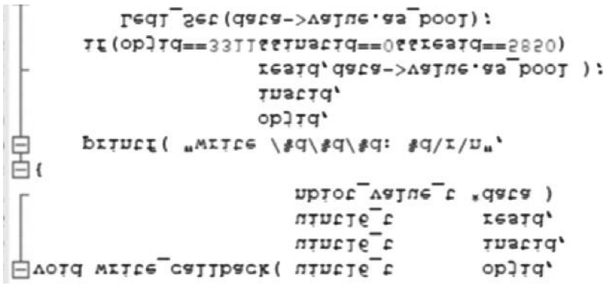
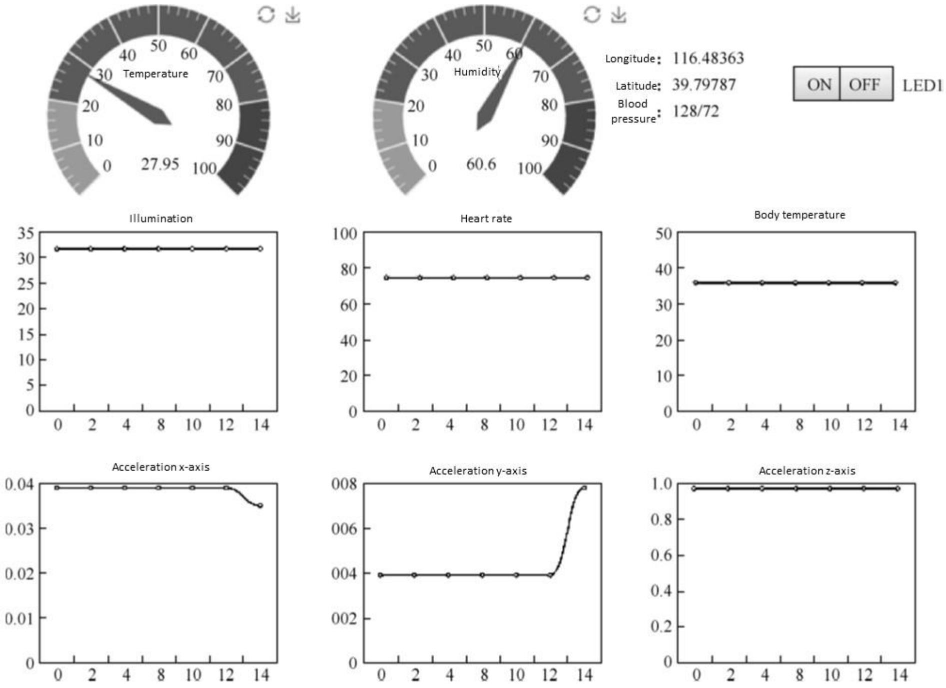


Figure 10. Key code to control the warning light on and off.

5.2. Web interface presentation

The client's web interface provides data retrieval and downstream control through the API interface provided by the platform, and stores the data in a MySQL database, ultimately realizing the control of the warning light's working status and the display of health monitoring data. **Figure 11** shows the web interface, which enables real-time monitoring of the wearer's health and remote control of the warning light, saving manpower and material resources while improving the efficiency of healthcare workers.



Longitude: 116.48363
Latitude: 39.79787
Blood pressure: 128/72

Figure 11. Web display interface.

6. Conclusions

This paper presents a NB-IoT-based health monitoring system for New Crown Pneumonia. The system is characterized by high reliability, low power consumption, high connection density and easy development. The test results show that the system is able to send the data collected by the sensors to the health monitoring platform using NB-IoT technology to achieve remote monitoring of the wearer's relevant health parameters, as well as intelligent monitoring and control of the warning light. The system is not only geared towards the development needs of smart healthcare, but also has a certain degree of universality compared to traditional solutions, and can be extended to smart meter reading, smart industry and other application scenarios, with good application value and market promotion prospects.

Conflict of interest

The authors declare no conflict of interest.

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REVIEW ARTICLE

2019 American College of Cardiology best conference

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ABSTRACT

As every year, the 68th American College of Cardiology (ACC) conference was held in New Orleans, Louisiana, from March 16 to 18. With carnival and jazz as the background, he convened the world cardiology again to promote knowledge by displaying a variety of scientific activities. More than 16,000 participants attended and 2,300 articles were received, many of which will undoubtedly change current clinical practice. It is also worth noting that the introduction of the guidelines for primary pretreatment of cardiovascular diseases emphasizes that acetylsalicylic acid is almost completely abandoned in primary pretreatment due to the lack of net profit.

We will briefly summarize some of the major scientific papers submitted:

1. Antithrombotic therapy after PCI for acute coronary syndrome or atrial fibrillation—Augustus test
2. Transcatheter aortic valve replacement and balloon dilatation in low-risk patients-partner 3 trial
3. Safety and effectiveness of STEMI femoral artery access: Safari STEMI trial
4. One month after drug-eluting stent implantation, clopidogrel monotherapy was compared with clopidogrel standard 12-month dual antiplatelet therapy. Stop DAPT 2 test
5. Results of a large-scale application based study using Smartwatch to identify atrial fibrillation: Apple heart research

Keywords: cardiology; meeting; summary

1. Antithrombotic therapy after PCI for acute coronary syndrome or atrial fibrillation—Augustus test

In patients with atrial fibrillation (AF) anticoagulation with coronary syndrome (ACS) or percutaneous coronary intervention (PCI), there are doubts about appropriate antithrombotic therapy[1].

Given the limited data on the use of apixaban in patients with atrial fibrillation and dual antiplatelet aggregation, the Augustus study was conducted to evaluate the effectiveness and safety in this regard. This is an open label, randomized controlled clinical trial involving 4,614 patients from 33 countries who have anticoagulant indications for atrial

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fibrillation with ACS or PCI and need to be treated with P2Y12 inhibitors for at least 6 months[1,2]. Patients who banned dual antiplatelet therapy and those who needed vitamin K antagonists (AVK) for other reasons were excluded: Prosthetic valves, moderate or severe mitral stenosis.

The design was a 2 × 2 factor analysis. During the initial open period, patients were randomly divided into taking 5 mg apixaban anticoagulant twice a day (2.5 mg twice a day, 2–3 in selected patients) or AVK with a target INR between 2–3. Subsequently, each of these groups was assigned to another double-blind faze for 6 courses of aspirin or placebo[1,2]. The primary objective was safety: The presence of major bleeding (according to the international society for thrombophilia and hemophilia) or clinically relevant minor bleeding, while secondary (efficacy) targets included death/ hospitalization and death/ ischemic event complexes[1].

The average age was 70 years old, women accounted for 30%, and CHA_2DS_2-VASc was 3.9 ± 1.6. P2Y12 inhibitors were mostly (90%) treated with clopidogrel. Related to the type of event, about 60% of patients developed ACS (60% underwent PCI) and 40% underwent selective PCI.

The findings were published in the New England Journal of Medicine by Dr. Renato Lopes (MD, MHS, Duke University, North Carolina). Compared with placebo group (HR 1.89; 95% CI 1.59–2.24; $P < 0.001$)[1], the main goal of apixaban was 10.5%, compared with 14.7% in AVK group (HR 0.69; 95% CI 0.58–0.81; $P < 0.001$ for non-inferiority and superiority) and 16.1% in aspirin group. When comparing the four treatment branches, it was found that the combination of AVK + aspirina had the most bleeding (18.7%), while apixaban + placebo (7.3%) had the least bleeding.

With regard to secondary goals, the incidence of composite death or hospitalization was lower in patients with apixaban than in patients treated with AVK (23.5% vs 27.4%; HR 0.83; 95% CI, 0.74–0.93; $P = 0.002$), while there was no significant difference between aspirin and placebo. The comparison of AVK versus apixaban and aspirin with placebo showed that the incidence of ischemic events was similar[1].

The authors concluded that among patients with AF, ACS, or PCI recently treated with P2Y12 inhibitors, apixaban antithrombotic regimen (without aspirin) resulted in less bleeding and hospitalization and no significant difference in the incidence of ischemic events compared with patients with AVK, aspirin, or both[1].

After consultation, Dr. Lopez said, “Due to concerns about massive bleeding, there are problems with the appropriate treatment of patients with AF and ACS and / or PCI. The results of this study provide additional information for doctors who treat these high-risk patients.”[3]

2. Transcatheter aortic valve replacement and balloon dilator valve in low-risk patients-partner 3 trial

Transcatheter aortic valve implantation (TAVI) has been positioned as an alternative to surgical aortic valve replacement (TAVR) for patients with severe aortic stenosis (SAS), who have severe, high and extreme surgical risks[4]. In randomized studies, TAVI was higher or not lower than TAVR and had a large number of records, including self-interpretation and balloon dilatation[4]. For patients with low surgical risk, a note study was published in 2015, which randomly divided SAS patients into TAVI (139 patients) or TAVR (135 patients) and coronary artery disease without intervention (5 patients)[5]. Among them, 82% of patients had a low risk of surgery (according to the association of Thoracic Surgeons [STS-PROM] score mortality predictor, the mortality was less than 4%). At 5-year follow-up, there was no significant difference in the primary endpoint of all-cause death, stroke and infarction (39.2% for TAVI vs. 35.8% for surgery, $p = 0.78$)[6].

Despite this result, the guidelines still recommend the use of TAVR in patients with low surgical risk[4]. On March 17, Dr. Martin Leon (MD, Presbyterian Hospital, New York) and simulti published part 3 of the study in the New England Journal of Medicine[7] to expand the evidence for the use of TAVI in this group.

This multicenter, randomized, 1:1 study compared 1000 low-risk SAS patients with TAVR using biological valves[7]. Low clinical risk was defined as STS-PROM < 4%. Patients with clinically fragile, bicuspid or monocuspid aortic valves or other patients who may increase the risk of surgical complications (severe aortic insufficiency) were excluded. Of the 1000 patients randomly selected, 50 were not included in the analysis, and most of them refused treatment or chose another non-research center. 7.9% of TAVI patients and 26.4% of TAVR patients underwent another operation[7].

The average age was 73 years old (male 69%), and the average STS score was 1.9% (7.8%). The primario target (including all-cause death, CVA or annual re-hospitalization) was 8.5% in grupo TAVI and 15.1% in TAVR group (HR 0.54; 95% CI, 0.37–0.79; P = 0.001), showing the perioperative period of TAVI[7,8]. Through a separate analysis of the main target components, all of these components have TAVI tendency[7].

Among secondary objectives, the results of two to 30 days showed that the TAVI group[7,8] had lower ACV rate (0.6% vs 2.4%; P = 0.02), ACV and mortality (1.0% vs 3.3%; P = 0.01), and new onset AF (5.0% vs 39.5%; P < 0.001). The annual mortality or ACV disability rate was 1% in the TAVI group and 2.9% in the surgical group (HR 0.34; 95% CI, 0.12–0.97)[7].

The hospitalization rate of TAVI implants was also lower than that of surgery (3 days vs 7 days, P < 0.001)[7], and NYHA functional grade, 6 minute caminata test distance and Kansas City heart disease quality of life questionnaire score[8] improved faster.

There was no significant difference between the two groups in terms of 30 days safety objectives (major vascular complications, permanent pacemaker implantation, moderate and severe paravalvular leakage or coronary artery occlusion). However, the rate of major or life-threatening bleeding was 3.6% in the TAVI group and 24.5% in the surgical group (HR 0.12; 95% CI, 0.07–0.21)[7].

It should be noted that the incidence of complete left bundle branch block was 32.7% in TAVI group and 8.0% in operation group (HR 3.43; 95% CI, 2.32–5.08), and the rate of slight valve leakage was also conducive to operation (29.4% vs 2.1%)[7,8].

As the main limitation of this study, the author mentioned that it only reflected the results of one year and did not evaluate the long-term deterioration of valve structure. “The final conclusion on the advantages and disadvantages of lvta compared with surgery depends on long-term follow-up,” they mentioned at the end of the report[8].

To highlight the relevance of the post presentation study, Dr. Braunwald mentioned, “This is a historic moment that everyone here should recognize. (...) I will tell our grandchildren that while we were there, we made amazing progress in caring for patients with aortic stenosis”[9].

3. Safety and efficacy of percutaneous coronary intervention for ST segment elevation myocardial infarction: Safari STEMI trial

Percutaneous coronary intervention (PCI) is the first choice for ST segment elevation acute myocardial infarction (STEMI). The latest guidelines take the radial artery pathway as the standard technology for coronary angiography and PCI. According to the results of the matrix study, there is level I evidence, in which the radial pathway is associated with reducing the risk of puncture bleeding, vascular complications and blood transfusion needs, as well as reducing mortality, thus strengthening the results of the competitive and rifle steacs study[10,11].

Considering that many intervention centers in the United States and Canada prefer femoral artery intubation (despite good evidence of radial artery intubation), the purpose of the safari STEMI study was to compare two intubations using new drug treatments and techniques (not previously included) in patients undergoing STEMI PCI[12].

Safari STEMI was a randomized, open, parallel allocation and blind evaluation study with a follow-up of 30 days. The primary goal was all-cause mortality, and secondary goals included CVA, reinfarction, stent thrombosis, or bleeding. 2292 STEMI patients (mean age 62 years, body mass index 28.2, female 22%, diabetic cos 17%) with symptom onset time < 12 hours from five medical centers in Canada were included in PCI. 1136 patients were randomly divided into radial approach and 1156 femoral approach. All patients received 160 mg aspirin, P2Y12 inhibitor load and 60 IU/kg (up to 4000 IU) of undivided heparin. Patients who underwent fibrinolysis, oral anticoagulant and previous myocardial revascularization surgery[12–14] were excluded.

It should be noted that in both groups, most patients were treated with bivalirudi sodium during surgery and then ticagrel; 68.2% in femoral artery group and 5.5% in radius group. The crossover rates of radius and femur were 8.1% and 2.3%, respectively. It is unclear how many contacts were made under ultrasound guidance using micro smear kits[12,13,15].

The researchers initially planned to include 4,884 patients, but the study ended early due to ineffectiveness, and there was no difference in the main goal (all-cause mortality within 30 days: 1.5% in radius group and 1.3% in femur group (P = 0.69). There was also no difference in secondary targets, namely reinfarction (1.8% radius vs 1.6% femoral artery, P=0.83), ACV (1.0% vs 0.4% P = 0.12), and massive hemorrhage defined by TIMI and BARC (1.1% vs 1.3% P = 0.74). They concluded that in STEMI patients undergoing primary PCI, the radial pathway is not higher than the femoral pathway, and appropriately trained surgeons should be able to use any of these pathways to achieve similar results[12–15].

Because the visit website sometimes needs to be changed during the operation, Michel Le May (M.D., Institute of Cardiology, Okawa University, Cana Da, FACC), the speaker of this paper, said, “I think it is important that the medical training program emphasizes the need to be proficient in the radial artery pathway of the femur, and may be under trained in performing one task, while constantly emphasizing the other task may lead to an increase in complications[14]”.

Claire Duvernoy (University of Michigan), a person trained in cross-femoral surgery, calls these results “sedatives”. She chose the radial approach in the elective patients, but when the opportunity was critical, such as STEMI cases, her first instinct was to use the femoral approach. Sunil Rao (Duke University), an advocate of wireless access, said, “Although this low-power trial did not show the difference between radius and femur, it is unclear whether really good femoral approach observance results can be obtained in clinical practice”. He also stressed that the early interruption of the study prevented us from reaching clear conclusions. Duvernoy mentioned to the media that the use of bivalirudin and closure devices in his hospital is not a standard practice, so inferring the results will be a challenge[16].

During the presentation, Le May showed the latest meta-analysis data, including Safari STEMI results: Patients with STEMI treated via radial artery had a lower risk of mortality, but the relative benefit was close to the unit (RR 0.78; 95% CI 0.61–0.99)[16].

4. Dual antiplatelet therapy 1 month after clopidogrel alone and clopidogrel alone Standard 12-month dual antiplatelet therapy with clopidogrel after drugeluting stent implantation. Stop DAPT 2 test

Antiplatelet therapy after cardiovascular intervention is a subject of current research, which is, inter Alia, why the most advanced coronary stents have a lower risk of thrombosis than previous stents. In addition, the risk of dual antiplatelet associated bleeding (DAPT) permanently increases with the continuation of treatment, and its mortality is comparable to new myocardial infarction (MI). The STOP-DAPT 2[17] study was proposed by Dr. Yukio Watanabe (MD, Kyoto University, Japan) on March 18 2019, but the results have not been published. This is a randomized, multicenter joint study conducted in 90 centers in Japan. Its main purpose is to demonstrate that after the implantation of the latest generation everolimus eluting stent, it is first treated with DAPT for one month, then treated with clopidogrel monotherapy, and then combined with aspirin and clopidogrel for 12 months.

The results given correspond to the preliminary analysis of one-year non-inferiority. The primary endpoint was the composite of cardiovascular death, myocardial infarction, stent thrombosis, CVA and bleeding, according to the thrombolysis score of myocardial infarction (TIMI). Secondary end objectives included independent analysis of the above ischemic and bleeding events. Patients with anticoagulants and a history of intracranial hemorrhage were excluded. Of the 6,504 patients who met the inclusion criteria, 3,045 patients were randomly divided into one of two treatment branches, of which 36 patients withdrew from the study. The final analysis included a total of 3,009 patients: 1,500 received DAPT for one month and 1,509 received DAPT for 12 months. The average age is 68, and only 21% of the female Nina population. 39% of the patients were diabetic and 62% had stable ischemic heart disease. 83% of patients used radial approach and 97% of patients used intravascular ima gene technology for angioplasty. According to credo Kyoto thrombotic risk score and credo Kyoto bleeding risk score, more than 90% of patients are at risk of thrombosis and bleeding.

The authors found that within one month, the net benefit of DAPT compared with Tada was 2.4% to 3.7% (non inferiority p value<0.001, superiority p value 0.04). Independent analysis of ischemic and bleeding events showed that the significant difference in combined results was mainly due to the reduction of bleeding events. However, in the one-year analysis of the second chemical event endpoint, one month of DAPT non-deterioration persisted (2.0% vs 2.5%, P non-deterioration dad=0.005). Primary and secondary TIMI bleeding was significantly reduced in the shortened DAPT group (0.4% vs 1.5%, non-inferior p-dad=0.002, dominant p-value=0.004). “In conclusion, ladies and gentlemen, the one-month DAPT followed by clopidogrel monotherapy provides a net clinical benefit for isquia and bleeding events (...) After the implantation of the latest generation of everolimus eluting stents,” Watanabe said. “This benefit is due to a significant reduction in bleeding without an increase in ischemic events[18]”.

The main limitation of this study is the low or moderate risk of ischemia in the study population, which makes it impossible for high-risk patients to obtain a prognosis. On the other hand, optimizing coronary intervention through intravascular imaging reduces the risk of stent thrombosis, but in our environment, this is a limited use strategy. Japanese patients also have a low risk of ischemia compared to European and American populations, which is emphasized in the report[18,19]. In order to understand the results of this work more widely, we look forward to its publication.

5. Results of a large-scale application based study using Smartwatch to identify atrial fibrillation: Apple heart research

The preliminary data[20] of this study was provided by Dr. Mintu Turakhia (MA, MD, Stanford University), which is the most expected data of con greso. With the popularity of Apple Watch and other portable devices, applications for detecting heart rhythm have been designed to identify common arrhythmias, especially atrial fibrillation. To this end, a new prospective single arm study was designed, involving 419,297 U.S. participants from November 2017 to July 2018. Includes iPhone 5 or later, Apple Watch series 1 or later, and standards aged ≥ 22. Patients with a history of atrial fibrillation, atrial flutter or anticoagulant therapy at the time of recruitment were excluded.

The primary objective was to measure the percentage of participants with irregular pulse detected by Apple Watch who were diagnosed with atrial fibrillation by patches recording ECG trajectories. As a research goal, we propose to use Apple Watch to characterize the correlation between irregular pulses and synchronously recorded ECG, and estimate the tasa in contact with health professionals after detecting irregular pulses.

Individuals who were interested in downloading the application and met the inclusion criteria were invited to participate in the study. The irregular pulse recognition algorithm uses the waveform of optical plethysmography to create tacograma (function of heart rate and time). If tacogram meets the irregularity criteria, prospective screening is performed to confirm the findings. In the case of five consecutive irregular heartbeats, through the application, participants will be informed of the premonition of irregular pulse, contact professionals through telemedicine, and be required to see a health center, or stick a patch that can record ECG to show the presence of atrial fibrillation (monitoring for at least 7 days). In this case, virtual access is planned.

Of the overall cohort, 42% were women (177,087), with a clear predominance of young participants (52%–219,179–between 22 and 39 years of age) of white race (68%–286,190–). A total of 2,161 participants (0.52%) were notified of the application, 21% of whom were women (461) with a predominance of 65 years of age (36%–775–). A total of 945 participants (44%) underwent virtual consultation and 30% were referred to the emergency department for associated symptoms. The remaining 70% had patch ECG recording placed, but only 450 were returned and included in the analysis (23% women). $CHA_2DS_2VASc \geq 2$ was 13% in the overall cohort (55,277 participants), increasing frankly to 33% in those who received irregular rhythm notification and in the ECG patch group (38%). The same behavior was observed for individual risk factors such as obesity, arterial hypertension, and diabetes mellitus.

In the 8-month monitoring results, the reporting rate of irregular pulso was very low, 0.52% (2,161/419,297 participants), which was significantly related to age (the reporting rate over 65 years old was 3.2%, 775/24,626 participants). When the ECGs of individuals with irregular pulse notification by the application were analyzed, only 34% (153/450) were confirmed to have AF, which implies that 66% had “false alarms”. The positive predictive values of ECG for the total cohort of Che atrial fibrillation were 0.71 and 0.84, respectively. As for the duration of AF (considered by the device when it was 30 seconds), 89% of the episodes lasted 1 hour with 25.5% lasting 24 hours. Another noteworthy aspect is that among patients with reported irregular pulse, 90 days of guidance (1,376/2,161, 64%) was completed, and 57% (787/1,376 pairs of drugs) contacted health professionals outside the application. In these cases, various behaviors were taken, such as starting new treatment (28%), referring experts (33%) and additional studies (36%). The reported adverse events were very low (1,038/419,297) and mainly unrelated to application (1,022/1,038).

These limitations were highlighted: After reporting, mayor abandoned expectations (64%) and provided fewer ECG patches than planned, which reduced the accuracy and actual design of the study, in which the data were reported by the participants themselves[21]. The registration target of 500,000 participants over 75,000 years of age[22] has also not been achieved.

With regard to the fact that only 34% of people were confirmed, Dr. Turakhia said, “This does not mean that 66% of people do not have atrial fibrillation. It just means that the FA may not have been there.” With regard to the new virtual experience, he stressed, “this study improves our understanding of how applications and portable technology work in the real world and to what extent it can detect prolonged atrial fibrillation. The low reporting rate of arrhythmias is an important finding because people are worried about over reporting, and we can see what happens when participants are notified”[23].

This virtual study is the first step in laying the foundation for future research, which will find suitable portable technologies to support cardiovascular health. “This really represents a paradigm shift in the way clinical research is conducted,” Turakhia said.

Conflict of interest

The authors declare no conflict of interest.

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REVIEW ARTICLE

The implementation path of intelligent rehabilitation under the background of healthy China construction

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ABSTRACT

The improvement of rehabilitation service capacity is an important part of the construction of a healthy China, and intelligent technology is a powerful means of rehabilitation development. This paper reviews the background of a series of national policies for the construction of a healthy China, analyses and summarizes the many shortcomings that currently restrict the improvement of rehabilitation service capabilities, and proposes the implementation path of intelligent rehabilitation. By expounding the service process of intelligent rehabilitation, and analysing in detail the intelligent technical means suitable for integration from the four key links of real-time health monitoring, remote home intelligent rehabilitation intervention, health classification evaluation standard system and health intervention standard system, the general framework of implementation path of intelligent rehabilitation is built. Taking hypertension rehabilitation as an example, the article introduces the intelligent rehabilitation practice exploration and reference model in three aspects: The research and development of hypertension intelligent equipment, the clinical research of hypertension rehabilitation and the construction of hypertension rehabilitation database. Finally, combined with the concept of intelligent interconnection of all things, the definition of "rehabilitation Internet of things" is proposed, and the time is right for intelligent rehabilitation in the context of building a healthy China.

Keywords: healthy China; rehabilitation; intelligence; wearable; hypertension

1. Introduction

Since the reform and opening up, our country's health undertakings have made new remarkable achievements, the level of medical and health services has been greatly improved, and the main health indicators of residents are generally better than the average level of middle-income and high-income countries[1]. However, factors such as population aging, changes in disease spectrum and in people's attitudes, have put forward new requirements for our country's health service level, and the health service system centred on disease treatment can no longer meet people's health needs[2]. Centring on the construction of a healthy China, rehabilitation has an innate mission in the transformation from patient disease treatment as the centre to people's health promotion as the centre. On November 27, 2020, the Intelligent Rehabilitation Professional Committee of the Chinese Association of Rehabilitation Medicine was officially established

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at the China National Convention Centre[3]. The special committee brings together the top talent resources in rehabilitation medicine and medical engineering in the country committing to building an integrated exchange platform for intelligent rehabilitation and exploring cutting-edge topics in the intersection of artificial intelligence and rehabilitation medicine. The in-depth integration of a series of modern intelligent technologies represented by artificial intelligence, virtual reality, network cloud and wearable sensing with rehabilitation will greatly enrich the means of rehabilitation evaluation and intervention, and make up for the deficiencies of rehabilitation medical services at the current stage.

2. Problems to be solved in rehabilitation in the context of building a healthy China

An aqueous homogeneous mixed salt solution containing $Cu(NO_3)_2{\cdot}3H_2O$ and $Mg(NO_3)_2{\cdot}6H_2O$ was prepared and simultaneously precipitated by drop-wise addition of 10% aqueous K_2CO_3 solution at a pH of 9.0 under constant stirring at room temperature. The resultant mixed Cu-Mg precipitate (precipitate of 10wt% Cu-MgO catalyst, ppt1) has been separated under reduced pressure and washed thoroughly with hot distilled H_2O until the complete removal of potassium ion. In a separate experiment, requisite amount of $Co(NO_3)_2{\cdot}6H_2O$ aqueous solution has been precipitated at a pH of 9 using K_2CO_3 under vigorous stirring. The obtained cobalt precipitate (ppt2) was filtered and washed thoroughly with hot water. Cu-Mg precipitate (ppt1) and Co precipitate (ppt2) were mixed in water under neutral condition and the resultant slurry was subjected to hydrothermal treatment at 373 K for 12 h followed by filtration with repeated washings. The precipitate was dried in oven at 393 K for 12 h followed bycalcination at 723K for 5 h. Similar procedure has been adopted for the preparation of other CoO promoted Cu-MgO catalysts. The catalysts were coded as 1CoO-10Cu-MgO, 5CoO-10Cu-MgO, and 10CoO-10Cu-MgO, here the numericals represents the loadings of Co and Cu by weight percentage. For example, 1CoO-10Cu-MgO represents a catalyst containing 1 wt% Co, 10 wt% Cu and the rsemaining balance MgO. With the decisive battle to build a moderately prosperous society in an all-round way, the party and the country attach great importance to health issues, and lay out a strategic blueprint for the construction of a healthy China in stages: On October 25, 2016, the Central Committee of the Communist Party of China and the State Council promulgated and issued the *"Healthy China 2030" Planning Outline*, setting the headquarters for the construction of a healthy China[4]; On June 24, 2019, the General Office of the State Council issued the *Healthy China Action Organization, Implementation and Assessment Plan*, which clarifies the implementation framework for the construction of a healthy China[5]; on July 15, 2019, the State Council issued the *Opinions on Implementing the Healthy China Action*[6], and the Healthy China Action Promotion Committee issued the *Healthy China Action (2019–2030),* which detailed the implementation of the healthy China construction[7]. This series of national conferences and documents from top-level design to implementation plan jointly convey the core idea of building a healthy China: To provide fair, accessible, systematic and continuous health services for the entire life cycle for the entire population. Rehabilitation is the comprehensive and coordinated application of medical, social, educational, and occupational measures aimed at maximizing functioning and reducing dysfunction in individuals with health conditions in interaction with their environment influence[8]. Strengthening the construction of the national rehabilitation system is one of the key contents of the construction of a healthy China. Early diagnosis, early treatment and early rehabilitation are essential components to achieve national health. The construction of our country's rehabilitation service system should establish the concept of "big rehabilitation", closely focus on the foothold of the whole population and the whole life cycle, based on community rehabilitation and guided by prevention[9], to provide accessible and affordable rehabilitation services for all.

However, the current rehabilitation service model in my country has many defects, which restrict the realization of comprehensive rehabilitation for the whole people. Summarizing the existing research in my country, there are mainly the following problems: Firstly, the service population is limited and the service stage is lagging behind. Rehabilitation medical resources focus on serving the injured, sick, and disabled. Healthy and sub-healthy people lack the awareness of rehabilitation and access to professional rehabilitation services. Inpatient rehabilitation is widely carried out, but early rehabilitation for many diseases is incomplete[10]. Secondly, the distribution of rehabilitation medical resources is uneven. In our country, the distribution of rehabilitation medical resources in institutions and regions is unbalanced. Large general hospitals are complete but grassroots hospitals are insufficient[11], and economically developed areas are leading and poor areas are lagging behind[12]. Thirdly, the function evaluation index system is not perfect. Lack of a complete functional evaluation index system, so that functional changes are only discovered after the development of functional disorders or diseases, and early warning cannot be used; the time-project-oriented evaluation system and generally low quality of personnel lead to poor problem-solving ability in grass-roots rehabilitation institutions and cannot be trusted by patients[13]. Fourthly, the evaluation and intervention methods are coarsened, and the iterative technology application lags behind. The commonly used rehabilitation evaluation methods are mainly based on qualitative and subjective judgments, and depend on the experience of the operator; the quality of rehabilitation professionals is uneven, and it is difficult to guarantee the homogeneity of rehabilitation and the effect of intervention[14]; the revision of assessment and intervention guidelines is time-consuming and labor-intensive to collect and organize evidence, resulting in a lag in the iterative technology application. Relying on the strength of any unilateral institution such as medical treatment, management or enterprise, it is difficult to solve the above problems in the short term, and new means or models are urgently needed.

3. Implementation path of intelligent rehabilitation

In recent years, technologies such as information, sensing, network and artificial intelligence have developed rapidly, driving the development of intelligent rehabilitation technology. Because intelligent technology has many characteristics such as informatization, networking, data quantification and automation, it has been widely studied and applied in clinical rehabilitation evaluation and intervention at home and abroad[15,18], rehabilitation informatization construction[19] and home rehabilitation[20,21], etc. However, the existing intelligent rehabilitation equipment or systems have relatively simple functions, and the intervention and evaluation focus on the rehabilitation of a certain disease, and the intervention of the whole population and the whole cycle of rehabilitation has not been realized. All kinds of equipment are relatively independent of each other, different equipment manufacturers stand on their own, and there is no unified intelligent rehabilitation technology standard and system. Therefore, it is necessary to propose an intelligent rehabilitation implementation path that systematically integrates various intelligent technologies, so that intelligent rehabilitation can better serve the goal of healthy China.

3.1. Service path

Intelligent rehabilitation should be positioned at the national level, the whole cycle and the homogeneity of rehabilitation. Rehabilitation network sinks into families, so that everyone can enjoy the accessible way of rehabilitation services; real-time health indicator monitoring is carried out, and rehabilitation intervention is moved forward, so that individuals can get rehabilitation intervention in the whole cycle; make high-quality rehabilitation resources reach the grassroots of all parties, and achieve homogenization of rehabilitation services. According to health influencing factors and risk indicators, it is possible to predict that individuals may or already have certain health problems in the future, classify and evaluate health problems, and give feedback to individuals and families. Provide scientific advice and approaches for individual health problems. For those who need intervention in medical institutions, referral channels are provided; for those who can be intervened at home, remote home intervention is carried out. At the same time, the intervention and health changes of individuals are tracked and recorded throughout the whole process, and daily real-time health monitoring will continue until the end of the round of intervention. see **Figure 1**.

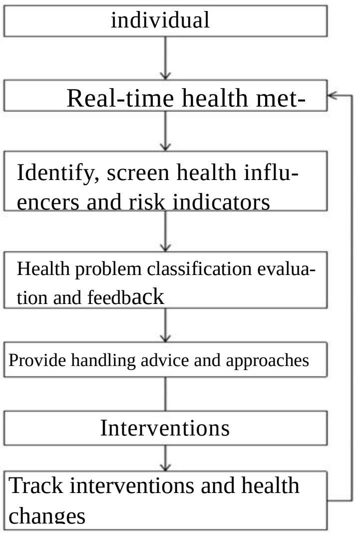

Figure 1. Intelligent rehabilitation service path.

3.2. Technical path

Real-time health monitoring

Based on the theory *of International Classification of Functioning, Disability and Health* (ICF), health status is the interaction between individual body structure and function, activity, participation and living environment[22]. Health monitoring indicators should include: Firstly, physical function and structural indicators such as heart rate, heart rhythm, respiration, blood pressure, balance, and joint activity of individuals; secondly, activities and participation indicators such as exercise, diet, and daily life; thirdly, environmental indicators such as home, travel, and working environment that individuals are exposed to. Wearable sensors are used to monitor individual indicators, and a Bluetooth module is integrated. The sensor data is transmitted to clients through Bluetooth such as smart-phones, and then to the cloud server through the wireless network. Medical institutions and family members can obtain data from the cloud through the network. See **Figure 2** and **Table 1**. **Table 1** lists some applications of wearable sensors in health monitoring. In addition, environmental sensors can also be used to monitor safety, activity, and environmental changes, such as the Oregon Centre for Aging Technology Smart Home and the University of Florida Gator Technology Smart Home[23].

Remote home intelligent rehabilitation intervention

The establishment of a remote home intelligent rehabilitation system is the basis for safe home intelligent rehabilitation intervention. Through short-range communication technologies such as Bluetooth, ZigBee, and WLAN, connect wearable monitoring equipment, smart phones, computers and other terminals, environmental sensing equipment and home rehabilitation intervention equipment, and then with the connection of the Internet, servers and medical institutions establish a remote home intelligent rehabilitation system. Some studies have carried out similar practices, but the target population is relatively limited and the function is relatively single. See **Figure 3**. For example, Li[33] used wireless Bluetooth transmission technology to connect the Biofeedback Therapy Instrument, Physiological Monitor and Host Computer, and with the connection of the server and the hospital through the Internet, designed a remote Home Intelligent Rehabilitation System for neuromuscular injury rehabilitation; Qiu et al.[34] connected the Leap motion controller, computer and cloud server to design a remote Home based Virtual Reality (HoVRS) for the rehabilitation of hand dysfunction after stroke.

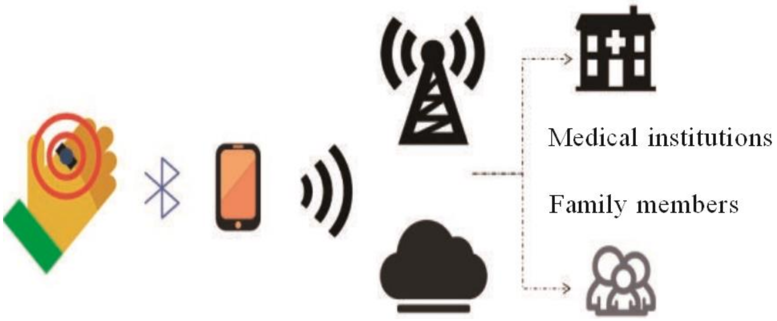

Figure 2. Schematic diagram of remote real-time health monitoring based on wearable devices.

Table 1. Application of wearable sensors in health monitoring

Indicator classification	Wearable sensor type	Application
Body	Photoelectric pulse wave biosensor	Monitor heart rate[24] and blood pressure[25]
	Flexible fabric integrated sensor	Monitor breathing[26]
Function and structure	Motion capture sensor	Monitor posture[27]
	Biochemical sensor	Monitor sweat composition[28]
	Electrochemical sensors	Monitor harmful substances in food[29]
Activities and participation	Chest strap swallowing respiratory sensor	Monitor diet[30]
	Acceleration sensor	Recognize motion[31]
Environment	Air quality sensor	Monitor air quality of individual exposure (ozone, particulate matter, temperature, humidity, etc.)[32]

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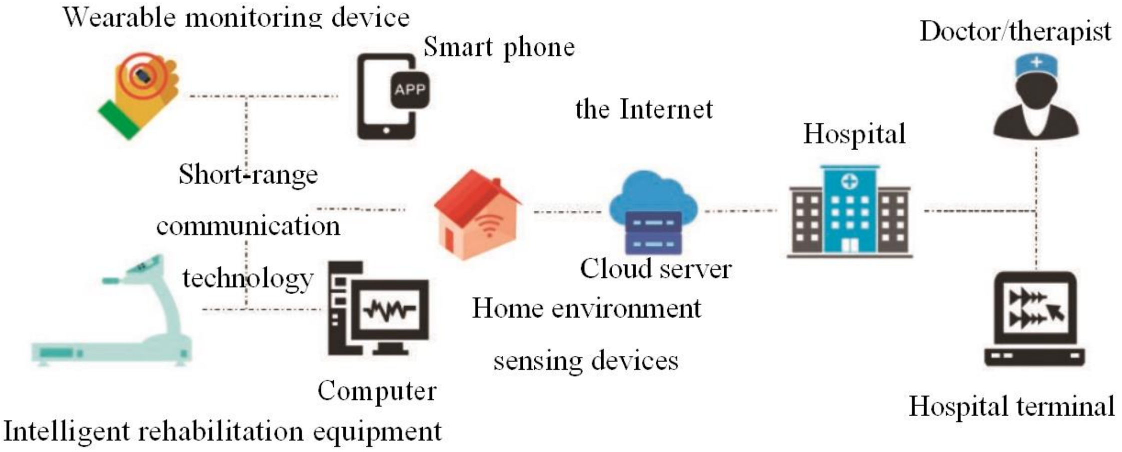

Figure 3. Schematic diagram of remote home intelligent rehabilitation system.

Health classification evaluation standard system

The ICF core classification combination is a list of categories selected from the full ICF framework that are most relevant for assessing and reporting functional information for a specific health condition or health care situation, for assessing the functioning of patients with a specific disease or in a specific health care situation[35]. The ICF core classification combination breaks the traditional scale evaluation thinking, and three-dimensionally describes the individual's health status from the perspective of body structure and function, activity, participation and environment. Using the ICF core classification combination to dynamically evaluate the health status[22,35], the identification results of each index can be converted into standardized ICF limit values according to the ICF framework, and the artificial neural network (ANN) can be used for standardized data analysis, thereby forming a standardized health evaluation method similar to the ICF core classification combination. The intelligent rehabilitation system conducts health monitoring and evaluation according to this unified standard, which is conducive to the analysis and exchange of data. See **Figure 4**[36].

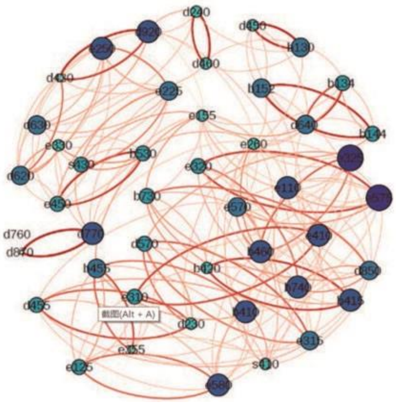

Figure 4. ICF network of chronic ischemic heart disease.

Health intervention standard system

International Classification of Health Intervention (ICHI), is a classification of health intervention from the World Health Organization Family International Classifications (WHOFICs)[37]. ICHI adopts the "goal-behaviour-means" three-axis analysis model to intervene on body function and structure, activity and participation, and environment. Each individual has a personalized ICF health network, and therefore a personalized ICHI intervention network. Provide an entrance on the client side to request medical interventions from medical institutions (e.g. body structure and function). Generate a rehabilitation management plan to provide home intervention (such as activities, participation, and home environment), and access the Home Intelligent Rehabilitation System. For intervention that require the intervention of other institutions (such as work and outdoor environment), the environmental intervention recommendations are transmitted to the relevant departments through the network and the cloud.

4. Intelligent rehabilitation practice exploration

In order to verify the feasibility of the implementation path of intelligent rehabilitation, we focus on hypertension rehabilitation to carry out a series of work, in order to form specific solutions in practice. Hypertension is the most common chronic disease in my country and the primary risk factor for stroke, myocardial infarction and even cardiovascular death[38], which seriously threatens people's health. The contents of hypertension rehabilitation include lifestyle improvement, diet control, psychological adjustment and exercise, which are very important for the intervention of hypertension. However, the awareness rate, treatment rate, and control rate of "three lows" are the general status of hypertension prevention and treatment in China[39], and the intervention of hypertension rehabilitation is not optimistic. The reasons for this are the lack of continuous blood pressure monitoring methods, the lack of early intervention concepts, and the lack of reliable hypertension rehabilitation guidance.

In response to these problems, we combined the ideas of intelligent rehabilitation, and carried out practical explorations from three aspects: The R & D of hypertension intelligent equipment, the clinical research of hypertension rehabilitation, and the construction of hypertension rehabilitation database. In the R & D of high blood pressure intelligent equipment, non-probation continuous blood pressure monitoring equipment is the focus of the current work. Firstly, cooperate with the materials science research team to study the use of new materials such as fabric electrodes and electronic tattoos to realize the non-inductive collection of human pulse waves. Secondly, by studying artificial intelligence algorithms such as ANN, the human pulse wave signal is converted into a continuous blood pressure value. This approach avoids the traditional cuff blood pressure measurement, adopts photoelectric sensors, piezoelectric sensors and other cuff-less sensing methods, and develops blood pressure monitoring equipment into smart wristbands, smart tattoos, etc., truly realizing non-inductive continuous blood pressure monitoring. The emergence of commercialized continuous blood pressure monitoring equipment will greatly increase the awareness rate of hypertension and better help everyone manage blood pressure for life.

In the clinical research of hypertension rehabilitation, characteristic exercise and respiratory rehabilitation therapy are the main research contents. Moderate-intensity continuous training (MICT) is the traditional recommended exercise method for hypertension[40], but the process of this method is tedious, and practice also shows that its compliance is not good. As a rehabilitation method for active respiratory control, respiratory rehabilitation therapy for hypertension requires the participation of body and mind. In recent years, more and more studies have confirmed that it is effective in improving blood pressure[41,42], but its promotion rate is not high. Therefore, research on effective, interesting and distinctive exercise and respiratory rehabilitation therapy will be able to make up for the lack of current hypertension rehabilitation methods. For hypertensive exercise rehabilitation therapy, study the effect of new exercise methods such as high-intensity interval training (HIIT) and circuit resistance training (CRT) with different intervals and target intensities on blood pressure, vascular endothelial function, and inflammatory factor levels, etc. Explore to establish the optimal combined exercise program and ultimately enrich the content of exercise, thereby enhancing the fun of exercise. For respiratory rehabilitation therapy, the research combines intelligent terminal APP, electronic airflow sensor, chest and abdomen breathing motion sensor and other hardware to convert the breathing training process into a visual game. The breathing training program was applied to clinical research to explore the impact of different breathing patterns on hypertension-related health indicators, so as to guide clinical practice.

In the construction of hypertension rehabilitation database, focus on macro-functional indicators and micro-physiological and biochemical indicators closely related to the progress of hypertension. Hypertension is a systemic disease of the cardiovascular system, and its progression may affect various functions such as walking, cognition, coordination and somatosensory. Physiological and biochemical factors such as vascular endothelial function, inflammatory factor levels, blood glucose and blood lipids reflect the overall healthy environment of the cardiovascular system and are inextricably linked to the progression of hypertension. Therefore, the establishment of a hypertension rehabilitation database from these two perspectives can gradually accumulate the index data of hypertension-related populations, which can be used to explore new markers for predicting hypertension and study the intervention mechanism pathways, which is of great significance for the long-term development of hypertension prevention and treatment.

5. Future of intelligent rehabilitation

The Internet of medical things (IoMT) refers to the intelligent and convenient connection of medical staff, patients, various medical equipment and facilities through the Internet of things and communication technology. Thus, it fully supports the automatic identification, positioning, collection, tracking, management, sharing and other functions of medical data, and better completes intelligent medical treatment and intelligent item management[43]. With the continuous development of intelligent rehabilitation, and the help of various communication and sensing technologies, “individual-equipment-medical institution” will be interconnected to form “rehabilitation Internet of things”. Combined with smart hospitals[44], smart communities[45], and smart cities[46], the future “rehabilitation IoT” will cover the entire scene of individuals and provide comprehensive health monitoring and rehabilitation services. Big data and cloud computing technologies will continuously optimize and iterate algorithms to adjust evaluation and intervention strategies by storing and analyzing the massive monitoring, evaluation, intervention and prognosis data generated by the “rehabilitation Internet of things”, making the system more and more accurate. Through the access of the cloud server, the government, scientific research and other related organizations will also have direct access to the health information of the whole population, which will provide a reliable basis for medical policy formulation, scientific research in the health field, revision of medical insurance standards and environmental governance, etc. See **Figure 5**.

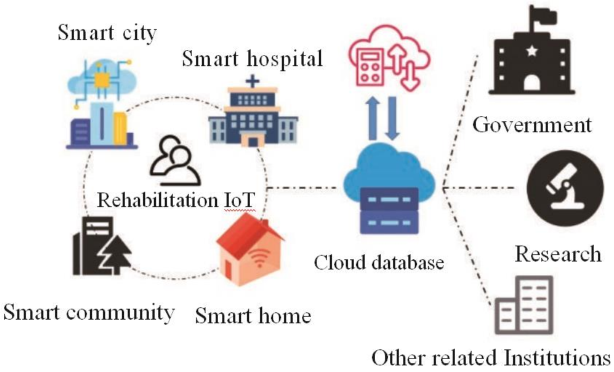

Figure 5. Future of intelligent rehabilitation.

6. Conclusions

The construction of a healthy China is an inevitable requirement for building a moderately prosperous society in an all-round way, and intelligent rehabilitation is an important means of popularizing rehabilitation services. The world is entering the digital age, and the construction and rehabilitation of a healthy China are inseparable from digital modern intelligent technologies such as wearable sensors, the Internet of things, big data cloud computing and artificial intelligence. This series of combination of intelligent technologies and rehabilitation will likely promote the development of nationalization of rehabilitation, the whole cycle of rehabilitation and the homogenization of rehabilitation. Apply WHO-FICs in the construction of intelligent rehabilitation, and endow intelligent rehabilitation with the intervention concept of “harmony between man and nature” to meet the needs of people’s comprehensive health. People need, technology integration, intelligent rehabilitation is the right time!

Conflict of interest

The author declares no conflict of interest.

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REVIEW ARTICLE

Overview of intelligent clothing and accessories technology system for the disabled

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ABSTRACT

The purpose of this paper is to explore the application of intelligent technology in the industry of the disabled. Through the systematic review of databases (Redib, Doaj, Redalyc, BMJ, BVS, Dialnet and PubMed), 11 articles were obtained, describing the intelligent technology in ves-tiles devices, which are designed to help patients recover. In an interdisciplinary field, especially in the field of social sciences, there is a new and underutilized phenomenon. This review shows that further research is needed to expand this topic.

Keywords: disability; clothing; smart clothing and accessories; technology

1. Introduction

From the perspective of sociology, clothing (clothing and accessories) is an inherent part of people’s life and plays a role of protection and display in daily life[1]. In addition, it uses psycho social factors related to body image to solve the problem of personal self realization[2].

But what happens when “dressing” happens in the field of disability?

Division occurs. On the one hand, an industry does not seem to know the needs, needs and expectations of a social group (those with specific preferences). On the other hand, “transparent” consumers try to adapt in some way to the clothes and shopping baskets created for the “other”, and “different” bodies encounter obstacles in choosing what to wear[3].

In addition, in this case, the focus of fashion design is on functional issues, limiting needs and expectations you will strictly follow the medical model compared with most people. It is clear and not overlooked that disability significantly affects the body in several ways. Therefore, it is difficult to wear different clothes when creating services for such a diverse group[4].

At the same time, disabled bodies cannot be considered synonymous with barriers and lack of economic benefits[5]. People have interests, demands and rights to participate in the environment independent of their physical, physical and sensory conditions[6]. There, clothing and accessories play an individual’s social performance function through three analytical variables (functionality, usability

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and aesthetics)[7].

In this way, technology appears in this social problem and provides different solutions for those who seek to dress/undress independently; help select clothing and accessories; communication and interaction with the environment. As Mann[8] named "visible computing" to understand functionality, comfort, aesthetics, sitting opposite conditions, mainly equal opportunities. In his article, the author defines "wearable" as an object that interacts and moves with users, and covers clothes through intelligent devices.

For Lobo et al.[9], this is a new design method, which combines information from different types of fields (engineering, biology, medicine, computer science, etc.) With different needs and expectations of users. The author describes three kinds of smart clothing:

(1) Clothing and its adjustment function, opening and closing;

(2) Portable apolipo protein i devices, such as orthosis, exoskeleton, etc;

(3) Portable intelligent devices, including sensors, nanotechnology, etc.

Especially in the medical field, Dittmar et al.[10] proposed the concept of healthy smart clothing, which refers to clothing that provides the possibility of using sensors to ensure that the treatment is non-invasive. For example, hair bands, T-shirts, socks, belts, shoes and other items made for rehabilitation purposes. In this case, it is important to emphasize the size and comfort of these clothes, as well as some related factors different from other clothes. Smart clothing is full of elements of speed, complexity, miniaturization, communication and new materials, which make small devices become active, low power, wireless or micro invasive devices. Smart clothing or accessories combine flexibility with functionality and use new fibers with specific properties (mechanical, electrical and optical).

In order to give full play to the relevance of intelligent technology in clothing, design must be user centered. Its goal is to identify real products and services according to people's needs, emphasizing not only practicality, but also the subjectivity of strippers[11]. For pullin, the design should also consider persons with disabilities and should focus on social models to change the environment. For example, glasses are for medical needs and have successfully become fashion accessories.

In the field of clothing, intelligent technology involves a mixture of electronic textiles, biometric materials, sensors and nano systems to resolve different health problems, reauthorize and daily activities without neglecting the aesthetic value[12]. The so-called "Smart clothing" created for the purpose of health monitoring, also use the intelligence system to generate interaction between the individual and his or her environment[13].

It is worth noting that the concept of intelligent technology is broad, and its richness is related to its application in medicine, engineering, psychology and other sciences, which use supporting standards according to the expected functions. It emphasizes the integration of basic skills into a coherent, low complexity and low cost system; guidelines for use in design involving interdisciplinary knowledge[14].

Particularly, dealing with intelligent design in clothing means moving towards a redefined system, combining tradition with clothing innovation. There, technology is positioned as a means of enhancing product potential in social change[15].

In this sense, the purpose of this work is to expand Argentina's knowledge in the field of fashion and social research on disability to a new theme. Detailed research, extracting relevant information, analyzing the quality of these studies and combining the main findings are the means to highlight relevant themes and trigger new directions in the psycho social aspects of fashion/disability.

2. Target

Within this field of analysis, the objective of this article is to systematically review the research that addresses the use of intelligent technology in clothing and accessories for people with disabilities.

3. Method

The premise of this systematic review is that the use of intelligent technology in the field of fashion design has a positive impact on the activities of daily life of persons with disabilities. To do this, research has focused on scientific articles that discuss the application of this technology in clothing and accessories designed to improve transparency, based on the recommendations of the prism declaration.

In this way, the following were included: Title, in which the publication was identified as a systematic review; (1) the structured summary; (2) the justification and objectives, where the knowledge of the subject and the implicit questions guiding the study were expressed (3 and 4); the method, with the eligibility criteria, the sources of information, search, selection, the data collection process and the variables for the data search (6 to 11); the results, with the selection and characteristics of the studies (17 and 18); the discussion, which presents the summary of the evidence, including the findings and the strength of the evidence of each study, limitations, conclusions, collaboration and financing (23 to 27). However, some items were excluded: protocol and registry; (5) the effects of assessing the risk of bias in individual studies; (12) summary measures; (13) the processes of synthesizing results, processing data, and combining results; (14) the risks of bias between studies (15 to 18 and 20 to 22); and the risk of bias in studies (19).

The search date focuses on English publications from January 2014 to July 2020. Considering that this topic has only recently appeared in Argentina, most publications are published in other countries, mainly the united states and the United Kingdom[16]. Articles in Spanish and Portuguese also have English abstracts. Therefore, the search is term centric: Smart clothes; disability and smart clothing.

The first searches were carried out in the following databases: REDIB-Red Iberoamericana de Innovación y Conocimiento Científico, DOAJ-Directorio de revistas de acceso abierto, Redalyc Red de Revistas Científicas de América Latina y el Caribe, España y Portugal, BMJ-open, BVS-Biblioteca Virtual en Salud, Dialnet and PubMed.

As a first search without specific filters and according to the descriptor smart clothing, a total of 763 articles were reached. Excluded were those in the areas of technologies related to architecture, education, accessibility, learning; in addition to general studies and literature review articles, congress and conference proceedings and those without empirical results.

Subsequently, smart clothing and disability reached 42 studies and the searches focused on the databases: BMJ-open, BVS-Virtual Health Library, PubMed. The justification is related to the objective of this study to analyze the applications of smart technology in clothing and accessories designed for people with disabilities. Thus, the studies relevant to this research are concentrated in these databases. Through the articles investigated, another descriptor used by the authors can be observed: Wearables in the databases: BMJ-open, BVS-Virtual Health Library, PubMed. With the purpose of expanding the amount of information, a third data exploration was made, with the terms: Smart clothing and wearables and disability. The search resulted in 14 investigations. Discarding duplicates and search restrictions, a total of 11 articles were found. This review was conducted between January 01, 2014 and July 24, 2020.

4. Results

The articles analyzed in this study prove the relevance of technology in fashion design, which aims to solve various problems related to disability in people’s life, help nurses and increase independent life. At the same time, these studies show that the development and use of technology is still new and is beginning to gain great significance in the field of rehabilitation.

From the selected records, we analyzed 11 articles, which determined that this work involves user centered design, and intelligent technology is a tool that can express sa in targeted clothing and accessories to actively supplement the health of patients.

The study describes the forms of portable technology: Shoes, insoles and gloves. They are adaptive and pony accessories that enable people to carry out rehabilitation activities more autonomously and improve independence. Some studies have revealed changes in the doctor patient relationship after the use of technology[17]. For example, use smart shoes to capture the autonomous walking parameters of patients with els (lumbar spinal stenosis); after surgery, it not only helps to accurately measure its functional level[18], because it produces economic and rapid effects in clinical information analysis[19]. In addition, gloves can replicate movement patterns and help restore weak hands[20]. In addition, intelligent insole is very important for the prevention of foot ulcer in diabetic patients. In this context, technology has become a progressive tool to prevent patients from dying in more severe disease stages[21].

These studies explore the possibility of functional and aesthetic design, as well as the possibility of social design, in which advances in science and technology can provide solutions through intelligence to enable persons with disabilities to meet their daily activities[17].

Without leaving aside the concern with consumption and how people observe the use of technology in their daily lives. The advantages and disadvantages, and to what extent it is a benefit for the family in relation to the care of people with disabilities, once technology generates independence and quality of life[22]. There are still many questions to be answered.

The methods used in the study describe: Qualitative and quantitative research with focus groups; prospective research, design feasibility assessment, experimental research and scope review, using qualitative and quantitative methods.

Reviewing each article, you will find that Hall et al.[22] in consumer behavior, they analyzed the impact of using smart clothing from the perspective of disabled caregivers and family members. According to the focus group interview, the results obtained by the author show that the adoption of technology in clothing involves various factors and environment (in terms of the role, rules and limitations of the technology system). It is essential that both consumers and caregivers receive adequate information. In addition, there is widespread concern about the use of smart clothing in caregiver recipient relationships, where personal interaction can be replaced by technology. However, the study did not rule out the benefits of freedom and control because it reduced some nursing tasks. On the other hand, there are benefits when patients use relevant information.

Ma et al.[23] found that in recent years, research on glove virtual experience development for hand movement and strength has increased. In this sense, this study proposes a hand rehabilitation learning system, namely safety gloves, a device that can learn the interesting movement of grasping and releasing objects. The author collects information from the data of people without such difficulties. The results show that the prototype not only provides information for learners, but also provides greater autonomy for the disabled in grasping and releasing objects.

Starting from the concept of wearable technology, Papi et al.[17] described the development of small electronic devices and accessories for clinical and rehabilitation purposes. They studied user centered design and the development of portable technology to monitor the functional status of knee joints in patients with osteoarthritis. As a result, it was found that many of the technologies developed did not consider the preferences of patients and health professionals, thus hindering more active use. However, few studies have explored this issue. At the same time, through the interview, the results show that all 21 participants believe that the product must be small, have the least interference to daily life activities, and be easy to use.

In order to gain a deeper understanding of the phenomena studied, Papi et al.[19] do a second investigation, in this case focusing on the preferences of healthcare professionals, as a means of identifying implementation strategies in the development of wearable technology more realistic to patients' needs, according to progress, treatment assessment and compliance monitoring. This is also a means to generate information related to clinical decision making. Through interviews with 4 clinicians, 4 physiotherapists and 5 orthopedic surgeons, the authors arrive at findings that support the use of wearable technologies to improve the current management of osteoarthritis, where efficacy is directly linked to the development of products that combine locomotion capability with ease of use and interface. The study presents that the potential use of wearable technology in the treatment of osteoarthritis is related to: The usefulness of the technology in clinical practice; the provision of patient data, time management, patient compliance in use, information properties, product specificity and the relationship of the professional with the patient.

Biggar and Yao[20] describe exoskeletons as one of the ways to improve the mobility of people with disabilities (stroke patients). In this case, the author uses virtual reality theory, through a system, with the development of patients at home, it has greater practicability and lower operation cost and space; by developing the intelligent prototype described in the glove, individuals can exercise their fingers more flexibly.

In order to quantify the functional level of walking ability of esl patients, Li et al.[24] independently developed an intelligent calibration design based on two algorithms according to oswestry preoperative and postoperative disability index scores. The collected results show that the use of shoes with sensors is not only helpful for treatment and nursing, but also helpful to obtain more effective clinical information to understand the functional level of patients in surgical treatment.

Biggar et al.[25] described the positive impact of intel technology on health, mainly in the field of persons with disabilities, where people face a series of obstacles that hinder more social participation. In order to change the health and environment, the authors believe that it is necessary to quantify the needs of end users, because they can determine whether the prototype design is beyond its therapeutic purpose, functional, comfortable and aesthetic. Based on these meanings, the study was based on a questionnaire of the QFD-Quality Function Deployment method, based on the variables: Joint movement, function, control, usability and a combination of remaining aesthetic and practical characteristics. From there, the objective was to collect information from patients with the purpose of arriving at a low-cost device that could be used at home, as an assistive tool and as a therapeutic aid. Also to generate information for therapeutic decision making[25].

According to the background used in the study, Lee et al.[18] observers found that about 33% of patients with esl were not satisfied with the clinical results after operation. This is due to pain and lack of function at the bottom. Therefore, they studied the use of technology in apparel design by evaluating a pair of smart shoes with five insole pressure sensors in preoperative ESL patients. The results indicate that smart shoes are a noninvasive, easy-to-use, and cost-effective treatment. In addition, it provides a complete analysis of the walking tests, which makes possible an evaluation with comparisons during the postoperative period.

Esmail et al.[26] described the use of clothing technology for persons with disabilities based on a comprehensive literature review and expert consultation. They believe that the design of smart clothing includes not only social and cultural functions, but also the need to collect enough information in the field of rehabilitation, so as to find solutions or methods to help these people live independently. The authors emphasize that there is little literature, which creates uncertainty and requires further research to promote social inclusion and participation.

Hatton et al.[27] studied the use of textured insoles in patients with diabetic peripheral neuropathy within 4 weeks to analyze walking performance and possible balance disorders. In this study, the researchers noted that the effect of traditional footwear on balance function in patients with diabetic peripheral neuropathy has not been widely studied. In this way, this work involves the development of smart shoes to improve the sensory environment of the foot as a viable option to help supplement the treatment of balance and walking problems in patients with diabetes, Parkinson's disease, multiple sclerosis, etc. Different prospective studies were conducted in a parallel group of 70 diabetic patients. The subjects were randomly divided into texture template group (intervention group) and smooth template group (control group). The results show the importance of the product to health and its relationship with user needs and key functions, such as the comfort and beauty of the product.

The review concludes with the work of Ming et al.[21] who describe smart technology as a preventive tool. The objective was to evaluate temperature controls and to be able to make timely and appropriate interventions for foot problems in people with diabetes over a 2-year period. The authors administered a control of slipper use with sensor insoles and the Smart Prevent Diabetic Feet application in 300 participants. The results achieved contributed to timely monitoring and intervention. It was also possible to build predictive models from the information collected by the sensor.

5. Discussion

This systematic review highlights a new topic in the field of disability and the social research of fashion design. It is worth noting that intelligent technology has begun the first step of building applied knowledge, which combines different disciplines such as computer science, medicine, rehabilitation, psychology, marketing, sociology and engineering to create thinking products that meet different needs and expectations.

These 11 articles (**Table 1**) show that the combination of clothing and technology goes beyond print and accessories designed for daily social interaction. With the increase of human needs and demands, the main function of protecting the body is open to other needs. Based on this view, most studies emphasize the relevance of people's participation in research. In product and service development, user centered design is an effective method of technology configuration and collaborative training.

It is worth noting that the use of intelligent technology still seems to be limited to the medical field and different rehabilitation needs. This has attracted people's attention because it shows that in all the progress of disability research, this phenomenon is bound by the medical model, ignoring people's strong demand beyond its limitations.

Faced with this, this systematic study questions the application of technology in disability. He pointed out that the analysis of the ways and purposes (advantages and disadvantages) of using smart clothing and accessories seems to be limited to one area. Although the role of rehabilitation is very important to the daily life of this social group, the increase of many technical equipment is crucial to the quality of life. However, we cannot ignore the demand for intelligent technology, which should not only improve users' skills, but also meet different tasks and promote greater social participation.

In addition, considering the different needs of persons with disabilities, it is difficult to understand how actively involved the fashion design process is. More systematic observation may be a more beneficial option. Therefore, those who produce intelligent objects should not be limited to the sensitivity of rehabilitation equipment, but should open up new ways of products and services for a more independent life.

Table 1. 11 articles

Author/Year	Method/Instrument	Population	Results	Knowledge domain
Hall et al. (2014)	32 participants (8 in each of the four focus groups) teachers and graduate students, administrators and students of midwestern universities in the united states.	Exploratory research based on focus group method for data collection and focus group interview	Wearable technology can be used to promote a healthier relationship between caregivers and people with disabilities, as well as surgery for people with disabilities.	Family and consumer science
Ma et al. (2015)	Experimental design. Safety Glove system	Twelve volunteers aged 20 to 69 had normal function and no pain in their hands.	The development of safety gloves is a new way to understand the learning system in the process of rehabilitation. In addition, it allows data to be collected for decision making.	Electrical engineering
Papi et al. (2015)	Focus group study; data management was carried out through thematic analysis of patient response.	21 cases of osteoarthritis	Patients' views on the development of intelligent accessories technology are related to understanding the fun, comfort and aesthetics of rehabilitation treatment.	Surgery and cancer
Papi et al (2016)	Quasi static research using inductive thematic analysis	13 health specialty	Transplantation technology improves the relationship with patients. Planned use helps manage time and decisions.	Surgery and cancer
Yao ming (2016)	Patients with cerebrovascular disease	Design and development of prototype	Design a nursing facility with strong adaptability and easy management for patients, so that they can carry out rehabilitation activities at home, reduce the workload of therapists and increase their dependence on nursing staff.	Biomedical engineering
Li et al. (2016)	An automatic rhythmic learning je was designed to estimate oswestry's disability index.	29 cases (11 males and 18 females) with LSS (lumbar spinal stenosis).	Application of za pato inteligent analyzer in surgical treatment of patients with esl	Physical medicine and rehabilitation, computer science and neurosurgery
Biggar et al. (2017)	Five-point questionnaire	13 cases of orthopedic rehabilitation	The information collected from patient information is a decisive factor in product development, both functionally and from comfortable.	Biomechanics and bioengineering in orthopedics and cardiovascular rehabilitation
Lee et al. (2017)	Analysis of parameters according to the Oswestry Disability Index (ODI) and the Visual Analog Scale (VAS).	Twenty-nine males and eight females were treated with ESL.	The use of smart shoes can accurately predict the surgical results of patients by optimizing treatment strategies.	Computer science, neurosurgery and neuromotor rehabilitation
Esmel, e t in los angeles. (2018)	The iterative analysis of the literature was reviewed and cooperated with the expert advisory group.	12 experts (experts in the fields of health, design, industrial manufacturing, health technology, rehabilitation and psychology (6 researchers, 3 representatives of the fashion industry (new technology, design, enterprise development and innovation), 2 postdoctors in rehabilitation medicine and 1 patient with spinal cord injury).	The research on intelligent fashion design information system is a means to create knowledge and improve the participation of the disabled in society.	Psychology and reauthorization

Hatton et al. (2019)	Randomized controlled trial, prospective vo, single blind parallel grouping.	70 cases of adult diabetic convulsive neuropathy.	The intelligent shoe device manually operates the non sensory internal environment of the foot through the insole, which is a choice to eliminate the balance and gait problems of nervous people.	Health and rehabilitation science
Ming et al. (2019)	Open label, prospective, alloy crimp, 24 months	300 patients with diabetes mellitus (type 1 or 2) and severe diabetic peripheral neuropathy	Using portable and intelligent devices to measure temperature is a good choice and helps to provide appropriate interventions for health care providers.	Kidney disease and hypertension, diabetes and endocrine.

It must be clarified that this issue is not intended to cover the multidisciplinary work of the submitted studies, because these studies serve as a reference and provide product opportunities for the rehabilitation, health maintenance, functional rehabilitation and improvement of the quality of life of persons with disabilities. In addition, research has shown that finding solutions from sensors, nanotechnology and new textiles can change the social, psychological and environmental barriers of disability.

This systematic review has created a space for scientific research on the use of disability, from clothing to intelligent technology. Therefore, the preciseness of methodology makes people realize that this is not a simple way to ask for help. It is necessary to understand new concepts, methods, comparisons and cognitive limitations, so as to make progress in the scientific field of the proposed phenomenon.

Conflict of interest

The author declares no conflict of interest.

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REVIEW ARTICLE

The regulation of the body by smart wearable devices and their social risk progression

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ABSTRACT

Smart wearable devices, as one of the directions of smart terminal development, show great potential for application and penetrate into all aspects of social life. In the application of smart wearable devices, the features of body discipline such as obtaining body data precisely to complete quantified self, human-computer interaction from explicit interaction to implicit interaction, monitoring of the body from expert dependence to technological dependence and the new human-computer relationship hidden behind them are increasingly highlighted. The social risk concerns of smart wearable device application will also come into play, which will lead to personal privacy leakage and technological risks. The social risks arising from the disclosure of personal privacy and technological risks, the loss of human subjectivity and the degradation of working capacity, the distortion of social life and the difficulties of social interaction, the deepening of the digital divide and the widening gap between the rich and the poor, the formation of a "digital leviathan" and the potential for public safety, etc., should be of sufficient concern to society.

Keywords: smart wearable devices; body regulation; human-computer relationship; social risk

1. Introduction

Intelligent wearable device, also known as a wearable computer device or wearable computer, originated in the 1960s. At present, there is no definitive and very clear definition of a smart wearable device, which is rich in form and function, and most of the research at this stage uses the definition given by the MIT Media Lab. According to the Lab, smart wearable devices are convenient user tools based on computer technology and multimedia wireless communication technology that connect to personal local area networks, detect specific situations or provide personal smart services with non-contrusive foreign body sensing input or output instruments[1]. In layman's terms, smart wearables are new smart terminals developed based on emerging technologies such as the Internet of Things, Wireless Sensors and Big Data. Unlike smart phones and other smart products, smart wearables make comprehensive use of interactive storage technology, which connects the device to the human body in a more convenient form, bringing a more natural and convenient experience to the

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user.

The Spanish thinker Odja Gasset pointed out in the first half of the 20th century that technology does not arise from the basic need of man to "live", but from the "superfluous need" of man to "live well"[2]. People often see what is objectively superfluous things as necessity[3]. This "superfluous need" has given rise to the birth and development of wearable technology, resulting in the high-tech industry of smart wearable devices industry. Smart wearable devices are the technical carrier of wearable technology, which covers many key cutting-edge technologies and is a complex and integrated computing technology system. It is a complex and integrated computing technology system. In addition to traditional technologies, many new technologies have emerged in recent years, including new materials technologies, integrated sensor technologies, sensing actuator interaction technologies, integrated data analysis technologies, lightweight and flexible textile-based solar cell technologies, new data-driven analysis technologies, and machine recognition and modelling technologies for human emotion expression[4]. It can be seen that comprehensive and crossover is the direction of wearable technology development. The application of smart wearable devices relies on the breakthrough of wearable technology principles and the integration and innovation of the whole technology system.

Since the 21st century, wearable technology has made breakthroughs and the wearable device industry has become increasingly mature. 2014 was one of the three themes of the International Consumer Electronics Show (CES), and Forbes also called 2014 the year of wearable technology. In 2019, China's Ministry of Industry and Information Technology officially issued 5G commercial licenses. 5G mobile technology, with its high bandwidth, low energy consumption, low latency, high coverage and interconnection of everything, has a profound impact on the development of smart wearable devices, and will further reshape the development pattern by enabling emerging technologies such as Artificial Intelligence, Internet of Things, Big Data and Cloud Computing.

It is expected that the wearable device industry is about to embark on an era of rapid development. Apart from economic considerations, we must pay sufficient attention to the impact of smart wearables on individuals and society. As an extension of the body's organs and functions, smart wearable devices will enhance the body's disciplinary function and a new human-machine relationship will be created. As the era of smart wearables approaches, it brings new experiences and social risks that cannot be ignored. Therefore, the social risks that smart wearable devices may cause and how to effectively prevent them become issues that we have to think about and study.

2. Smart wearable devices for body regulation

2.1. Access to body data for accurate completion of the quantified self

Unlike the smart mobile products of the past, smart wearables as extensions of body organs and extensions of body functions enable the visualisation and externalisation of bodily cognitive processes, satisfying the modern need to understand the self with precision. Wiener[5], the father of cybernetics, pointed out that the use of the body as an integral part of afferent and efferent information systems was an important shift in communication cybernetics in the 20th century. In the 21st century, we can already feel changes in the body and external environmental factors at any time through wearable sensors and access relevant body data autonomously without disturbing the individual and the environment in which he or she lives. The idea of dataism embodies a broad belief in the objective quantification and potential tracking of various human behaviours and social phenomena through online media technologies[6]. The quantification of natural phenomena through natural science and quantification characterises the 'quantification of nature', which, in the context of the increasing maturity of wearable technology and the upgrading and widespread use of the wearable device industry, is being upgraded to "Quantified Self". The concept of "Quantified Self" was introduced by Gary Wolfe and Kevin Kelly of *Wired* magazine in 2007, advocating people to track and explore their own bodies through digital and devices, and to shape it into a movement of self-knowledge and self-measurement, making it a way of life for ordinary people. At present, the most important of the wide range of Quantified Self tools is the smart wearable device, which has become the authoritative provider of data to monitor the body, so that people can accurately measure their bodies based on data instead of feelings, reflecting the "body data" feature and the trend towards self-tracking. People can use the technology of Quantified Self to self-monitor sleep time, miles walked, calories burned, and medical visit management. As a social and cultural phenomenon, the Quantified Self is not only a mirror to understand oneself, but also a way to connect and share data with others. Quantified Self technology for smart wearables is a new way of life, creating a world of continuous quantification where people can generate a range of data during leisure, entertainment and exercise, making their daily lives more visual and measurable, thus completing the Quantified Self.

2.2. The shift from explicit to implicit human-computer interaction

Smart wearable devices can constantly monitor and record people's daily body data by connecting to mobile smart devices, presenting an interplay between "body—technology—data" and breaking the boundaries between people and devices, a phenomenon that Donna Havila[7] calls "cyborgs". People are driven by body data to self-construct their own bodies, and in the process, individuals gain satisfaction and enhanced individual responsibility by having access to body data to understand their own physical condition. In 1996, Nicole Kayan further explored the implicit theory of human-computer interaction and proposed an implicit theoretical framework. Due to the limitation of the device wearing position and the surrounding interaction space, explicit interaction based on multiple points for touching the screen needs to open up a new path, namely implicit interaction, which is a form of interaction where the smart wearable device itself senses the context of use and actively infers the user's intent as its system input. For example, in the context of a user raising their arm to look at a watch, the difference between implicit and explicit interaction is clear: In a wrist-worn product designed with implicit interaction, the screen automatically wakes up to display the time and other information after the user has made a motion to raise their arm, reflecting the implicit interaction design concept of the device actively inferring the user's intentions. In contrast, explicitly designed wearable products require the user to shake their wrist to light up the screen, making the implicit interaction more natural and effective. The shift from traditional explicit interaction to implicit interaction for smart wearable devices will expand the dimension of interaction with smart wearable devices and bring a better interaction experience to users.

2.3. Body monitoring shifts from specialist dependence to technology dependence

Canadian sociologist Zwir Frank has classified the body into four ideal types of bodies: The body of interaction, the body of mirroring, the body of domination, and the body of regulation, based on the body's self-control, degree of desire, and the body's relationship with the self and others[8]. In this framework, smart wearables are also highlighted as a medium of communication between self and data, and their function of self-tracking and discipline. As a practice for managing the body, smart wearables help users create a "self-lab" of the body, assisting and guiding individuals to observe their physical responses, daily activities and environmental experiences[9]. Smart wearables not only monitor people's daily physical rhythms, motor behavioural trajectories and psycho-emotional conditions, but also view the body as a sophisticated instrument that can be augmented and expanded. Individuals use sensors and data systems to monitor, collect and accumulate bodily responses and to engage in self-reflection and regulate the practical activities of the body. By monitoring people's physiological conditions and movement data, smart wearables enable the body's desire for energetic perception and control, moving people from expert dependence to technology dependence. For example, Eyra, a Swiss smart wearable development company, has released Horus, a smart wearable that helps visually impaired people to "see". Horus can recognise text, objects, faces and scenes, and when a blind person reads a book or magazine, he or she can listen to it instead of seeing it by aligning the device to the right position according to voice prompts, giving the visually impaired the ability to live their own lives. This means that visually impaired people can no longer rely on medical specialists for their daily lives, and technology is in a sense becoming a substitute for specialists, with technology being given the title of "expert". When viewed from the perspective of "vision restoration", there is no fundamental difference between smart wearables and medical specialists. As the intelligent, automated, data-driven and visualised nature of wearable technology lowers the barrier to entry for interpreting physical signs and recording data. Are we moving away from reliance on specialists and towards reliance on technology? This is the hidden implication of smart wearables for bodily regulation. While we are fully aware of the appearance of smart wearables for body discipline, we should also be fully aware of the human-machine relationship that lies behind it.

3. Human-machine relationships in smart wearables

In *The Quest for Technology,* Martin Heidegger points out that technology exists before man, and that the essence of technology is a natural way of unmasking, i.e. a "seat", a kind of placement that forces man. When technology becomes the "seat" of human society, the body naturally escapes the fate of being "inscribed" by it[10]. Martin Heidegger repeatedly mentions that the threat of the "seat" has touched man at his very essence, forcing him and the world into the path of the "seat" of technology. In a sense, the "seat" he called is technology and the complex set of cultures and institutions behind it[11]. As a high-tech application that makes people's lives more convenient, the emergence of smart wearable devices reveals not only the most sophisticated machines created by technology, but also the various cultures and institutions associated with this technology. In other words, the commercialisation and popularisation of smart wearables has led people, without exception, to a state of "regulated" existence, governed by the powerful will of technical reason behind the technology itself. Conversely, smart wearables control everything according to the technical rationality inherent in the technology itself, and people do not voluntarily ask to enter the path obscured by the machines. This technically rational will of power dictates social reality, thus obscuring the true nature of people and things, and destroying, distorting or even losing the very nature of what makes people human[12]. On the surface, it is true that people are using smart wearables to achieve various purposes on a practical level, but at a deeper level, they are replacing them with smart wearables that coerce people to acknowledge and adapt to their one-dimensional conceptions, logic and culture of technological rationality. In modern technology, human manipulation of the external world has reached unprecedented levels, and through technology humans have not only caused the external world to change course, but they have also been conditioned in the process to lose themselves and their human essence in various technological devices. The relationship between man and machine therefore needs to be re-examined.

The development of technology lies in exploration and research, which implies the manipulation and domination of its object by the researcher. Technology dominates nature through premeditation and calculation. At the same time, in this rational planning and calculation, humans themselves are placed at the mercy of it. In this way, there is a "host and guest heterogeneity" between the machine, nature and humans, and the machine is rooted in the demands of a compelling logic[2]. This means that smart wearables also "seat" humans according to their own needs, such as posing norms of behaviour for their controllers, and posing educational institutions accordingly. The use of wearable technology is rapidly spreading to all areas of human society, bringing about a number of significant changes to the human condition, as well as a quiet shift in what people talk about and how they perceive the world. Using wearable technology, humans have created smart wearable devices and their ancillary items that form a rich picture of the world. In an era of new technologies, the vast array of images created by technology has overwhelmed the human presence, making the original harmony between heaven and earth and man fade away. The "ride" of technology has deprived both people and things of their self-contained state, becoming a picture of the world that can be contrived by technology. The power of the machine has forced us to abandon the pursuit of humanism and to dismantle the subjectivity and sociality of the human being. We do not deny and reject the rich world picture that smart wearable devices bring to people, but we must maintain a more urgent inquiry and contemplation on the human-machine relationship in the development of wearable technology from the point of view of the self-sufficiency of existence.

For human beings, the body is the self-contained basis and medium through which we perceive things, and it is through the perception of the body that we establish some kind of connection with the outside world. When we talk about the body, what are we talking about? The contemporary philosopher of technology Ihde[13] distinguishes between "body" as "body one" and "body two", with the former referring to a phenomenologically understood "living body" that "exists in the world" and the latter referring to the "body of rights" that we construct in politics, society and culture. He presents that what links "body one" and "body two" is the relation of embodiment as a technology. The embodied relationship is the transformation and enhancement of the body's perception through technology, and is the most fundamental relationship between human beings and technology. In other words, in addition to the connection between "body one" and "body two" through the real perception of the body, the connection between the two can also be achieved in a technological dimension through scientific perception, or, the materialized "virtual body" is used as a mediator for the unification of the two bodily levels[14]. Ihde[13] summarises the diverse relations between man, technology and the world in the relational formula "man—technology—world" in order to formulate an embodied theory of technology. It focuses on the intentionality inherent in the interaction between humans and technology, i.e., technology as a mediator regulates the relationship between humans and the world, and technological intentionality makes embodiment possible, a theory that reflects the human-computer relationship of intentional interaction. As Martin Heidegger's hammer, Maurice Merleau-Ponty's cane and Don Eade's spectacles illustrate how technology expands the range of human perception, the hammer, the cane and the spectacles all embody the intrinsic intentionality of technology and are contextually integrated into the human perceptual landscape, becoming an extension of the human body's functions. In the "man—technology—world" relationship, the technology mediates the way in which the person perceives and experiences the world, acting as a means of "bridging" between the person and the world, in contrast to the person as the subject and the smart wearable device as the mediator, linking the two in the embodiment. In contrast, the human being as a subject and the smart wearable device as a mediator connect the human being and the world as a whole, with the boundaries between the two gradually "dissolving". The action of the human is the action of the body, the action of the technology is the action of the human, and the world is the context in which the action of the human and the technology is generated, and these three form a stable interaction[15]. In human-computer interaction, embodiment theory focuses on the interaction between the body and technology, and on how human bodily functions are "transformed" by technology, i.e., the improvement and expansion of human behaviour by technology. For example, e-skins in wearable technology devices are ultra-thin electronic devices with skin-like soft hardware that can produce a sense of touch, with built-in smart wearable technology that connects the human to the outside world and becomes an “extender” of the natural tool of the “human” to compensate for the human tool itself has structural deficiencies. It can be attached to the surface of a device to act as a coat, and can also be used in human repair surgery for severe skin trauma, where the human body is technologically “customised” and the technological device is constantly interfering with the range of perceptions and senses. This new artificial skin senses changes in external pressure, temperature, etc., and sends signals to the human brain to create an almost realistic sense of touch, and the technology completes the body’s extension function. The various elements of the electronic skin act as intermediaries for the transmission, enabling the reception, conversion and transmission of tactile signals, thus allowing the human body to better feel the forces of the outside world.

In contrast to the embodied relationship, the disembodied relationship examines the ways in which technology maps out the body, with technological disembodiment objectifying, marginalising and picturing the body through technology. In the virtual reality game scenario of head-mounted AR devices, the player wears this device and interacts with the “virtual opponent” presented in the device, and the device terminal appears as a “third party” forming an “alien relationship” with the person. Moreover, the player can switch his or her identity in this field at will, and the relationship between the person and the technology is disembodied. In distance online education interaction, the application of virtual reality in wearable technology makes the mode of operation “move” from offline education to online education, and virtual reality creates a spatial field of “presence” learning for online learning, with the user sitting in front of the device as an “electronic person” , communicating and interacting online in an “immersive” manner on behalf of his or her object. Although the virtual field can recreate a simulated environment and reveal holographic dynamic content, it is in fact disembodied, according to Don Eade’s logic. Hubert Dreyfus holds a similar view, arguing that any form of online education is disembodied because it lacks the “atmosphere” of face-to-face communication between teacher and student[16]. Clearly, Don Eade’s view of the relationship between the body and technology is at an empirical level, considering the two to be separate and external to each other and categorising them as “embodied” and “disembodied”, without seeing a symbiotic relationship between the body and technology. In fact, the relationship between body and technology should be understood in a broader sense, which should be not limited to the impact of machines and devices on the body, but also realize the formation of a new human-machine relationship in the application of wearable technology.

The relationship between the body and technology reveals that material technology is a part of the technology of the body. In terms of the relationship between body and technology, the body is the technology of “nature” and partly the ontology of material technology, the body constructing itself as a technological being in a long natural evolution. Indeed, Martin Heidegger’s perspective can be described as an implicit philosophy of the body, identifying the possession of human intelligence with the possession of the self-body. As the relationship between technology and the body is questioned, the relationship between technology and the body must be reconceptualised. In the case of smart wearables, bodily skills are not only seen as a fundamental technology where technology and the body can no longer be distinguished, but external tools can also intervene in the self-body as an intrinsic functional element. In the field of phenomenology, the scientific world and the real world are essentially a confrontation between material technology and bodily technology. Before the advent of the Smart Era, digitisation and symbolisation were often understood as “de-bodied”. However, since the advent of internet and artificial intelligence technologies, especially smart wearable devices that track, measure and visualise body data, have changed the traditional perception of digitisation and people tend to understand the characteristics of digitisation as “digitisation of the body”, resulting in body technology. Body technology is the embodiment of the embodied relationship between the body and technology[17]. Maurice Merleau-Ponty argues that “all technology is bodily technology”, and if we accept that technology can be divided into materialised technology and bodily technology, this means that bodily technology or bodily skills will become an important part of the category of technology. The act of immersion of the subject in the world leads to the fact that tools are no longer external objects of the self-body, but can be classified as an intrinsic element of the self-body. This external relationship is broken, meaning not only that the external technology enters the body internally, but also that the body itself will enter the realm of technology that previously remained external. The self-construction of the human being is first and foremost the self-construction of the body, and usually when we talk about technology, we are always referring to some tool, device or apparatus. In fact, the most basic tool, the most basic technology of the human being is our body technology[18]. This provides theoretical support for body technology as a basic category of technology and a theoretical perspective for understanding the human-computer relationship in smart wearable devices, as well as the implication of smart wearable devices as body technology.

The path of technological development is fraught with uncertainty, with new technological developments creating new machines and devices and forming new human-machine relationships. In the era of Artificial Intelligence technology, with the paradigm of smart technology development evolving, the autonomy of technology increasing, and the human-machine relationship more complex, smart wearable devices may unwittingly become devices that manipulate individual humans and human society as a whole. Due to this existence of possibility, the development and application of this revolutionary and evolving AI technology in large numbers will create more uncertainty and the risk of machine alienation in society. In a sense, the human-machine relationship formed by the intermingling of humans and machines does not involve the realm of social risk, but in the process of applying smart wearable devices, it is often intertwined with multiple types of social risk, creating an inextricable link. As human-machine collaboration becomes a norm and expands beyond humans themselves, penetrating deeper into the realms of personal privacy, social life and public safety, the human-machine relationship evolves into a threatening condition that poses unprecedented risks to the application of smart wearables. These risks could change the direction of smart wearables, and it is important that these risk paths are identified and prevented as early as possible.

4. The social risk progression of smart wearables

Smart wearables act as a “paradox” for humanity itself. The more they develop and penetrate into everyday life, the more the threats and risks become increasingly clear. Will the “technological leviathan” created by technological innovation lead to a greater of the dilemma? The German techno-sociologist Ulrich Beck[19] has conducted a comprehensive study of the social risks posed by technology, arguing that contemporary society is a risk-ridden society. By considering and interpreting the social risk path of smart wearables from the perspective of risk society, we can improve our ability to reflect on social risks, which is important for us to recognise and prevent the social risks that smart wearables may bring in their development.

4.1. Unclear attribution of responsibility for personal privacy breaches and technology risks

Privacy is the “foundation of human rights” and the emerging technologies of modern society, represented by Big Data, pose an unprecedented threat to personal privacy, which has intensified widespread privacy concerns and lack of privacy protection. Wearable technology uses big data as a means of analysis, and the prying and exposure of Big Data to privacy is inherent. There is a risk that personal body data information will be made public, either intentionally or unintentionally, under the erosion of Big Data, putting personal privacy under serious threat. In other words, data collection facilities of all kinds and various expert systems can easily, exhaustively and meticulously access personal privacy. Massive amounts of data are constantly being mined and utilised as the core of technology and personal information, constantly supplying information value when interacting with it, putting the security of personal privacy at risk. Clearly, the use of smart wearables has exacerbated the risk of personal privacy breaches. The use of Google Glass, a smart wearable device, has revealed itself to be a troubling issue for personal privacy, and some public places have introduced bans on wearing Google Glass inside due to the protection of personal privacy. Google Glass' first face recognition application, NameTag, allows users to obtain information such as a person's name and occupation by simply looking at a person nearby. With NameTag, Google Glass users can read data from various social networks and shopping platforms, and people's identities, behavioural habits, life paths and shopping history are easily accessible. This group is vulnerable to discrimination if sensitive personal data, past medical history and criminal convictions are leaked and "shared" by those with an ulterior motive. Body "datafication" and "glass man" is not only a medical gaze, but also a daily life in what Foucault calls "surveillance society". This raises the question of whether the right to privacy, as a fundamental right of the individual, is still the basis of individual freedom in the age of intelligence. Clearly, it is worth considering how to strike a balance between the use of smart wearable devices and the protection of personal privacy.

The kaleidoscope of wearable technology is becoming increasingly colourful, making it easy for users to immerse themselves in an optimistic and peaceful atmosphere. Some developers use the technical advantages of smart wearable devices to package them as portable tools that can do anything, and people's blind admiration for wearable smart products makes users ignore its hidden technical risks, and once there are technical risks, it is difficult to clarify the subject of responsibility. Smart wearable devices have unavoidable technical risks in terms of their own technical characteristics, the most direct of which is the risk of technical safety liability. Due to the complexity of wearable technology, it becomes a problem to divide the responsibility. When it comes to assigning responsibility, smart wearable devices face a dilemma in terms of safety. Due to the technology's own defects and safety hazard identification errors prone to human hazards and safety accidents, whether the technology will cause safety accidents should be the primary consideration of R & D personnel. Smart wearables themselves cannot be the subject of liability; they are simply "imbued with codes written by programmers for specific purposes[20]". And even if they have the ability of self-updating and upgrading, they are only the codes and algorithms written by programmers to achieve it. In traditional ethical codes of responsibility, the subjects of responsibility are undoubtedly the designer, manufacturer and seller. Whereas in the development and application of smart wearable devices, there is a single subject of responsibility at each step of the process, and because of the complexity and systemic nature of the technology, it is impossible to clarify the subject of responsibility once the issue of attribution arises. Caught by value bias, interest pursuit and misconceptions, developers may weaken their willingness to take responsibility, or even defy and deny social ethics and legal norms, which is bound to disrupt the economic and social order and cause greater social harm. Therefore, the question of to what extent developers of smart wearable devices should take responsibility for society and how to conduct responsible technological innovation needs to be addressed.

4.2. Loss of human subjectivity and degradation of labor capacity

The commercialisation of smart wearables has led to the increasing invasion of machines into human life, bringing humans into an intelligent state of being. The development of smart wearable devices has created more and more “organic” intelligent machines, which are fed with human knowledge and intelligent algorithms, and are no longer in a simple mechanical human-machine relationship with each other, but with an intelligent interaction context. As inorganic beings, smart wearable devices intervene in the human state of being, which may lead to the social behaviour of human beings being subordinated to technology, the value of human beings themselves being devalued, the status of human subjects being shaken, and their “ontological issues” being affected to a greater or lesser extent[21]. Human beings are being reshaped by intelligent machines, and the definition of “human” may be different as a result. In an era where everything is computable, if the algorithms of technology have more supremacy than human beings, the “seat” of technology over human beings can lead to a crisis in the perception of human identity. It raises the danger that we no longer see ourselves as ends in themselves. Instead, we begin to see ourselves as devices to be used by people and as tools to be used by people[22]. The push and “seat of the pants” of wearable technology gradually deprives humans of the ability to perceive and judge the world around them, and due to the complexity of the limited rationality model and human cognitive processes, there is a risk that human perceptions will gradually become blurred and one-sided. In addition to obedience to technology, humans no longer possess judgement and negativity, and know themselves and become “one-way people” who transcend reality[23], and they endow machines with their own unique intentionality from the superficial to the profound, from the superficial to the profound, so that they can take on human subjectivity and values. In this way, the natural human body is being mended and modified, and the unique emotional creativity of humans is being “stolen” by intelligent machines. Technology is manipulating the way in which man understands society, transforming “Man is the highest essence of man”, and defining the historical destiny of humanity. The “logic of the machine” deviates from the expected development pattern and the anti-subjective effect becomes stronger. The expansion of technology in all fields gradually marginalises the human being, and the constant development of technology becomes an integral part of the human body or social regulation, forcing the human being into an era of digital existence. Are machines the “liberation” or the “replacement” of man? The new relationship between man and machine and the risk of the loss of human subjectivity due to the blurring of the human-machine boundary should be a matter of concern.

The substitution of human labour is the origin and the ultimate destination of technological development. The principle that labours creates man tells us that it is labour that creates mankind, and if mankind stops working, mankind will gradually degenerate. In the era of smart wearable devices, if humans no longer focus on improving their creative capacity, but rely on technology, the evolution and development of human society will fall into the trap of technology. It is true that the replacement of human labour by smart wearables is only a partial replacement, but the human choice of smart wearables is itself the result of an inertia-driven approach. Odja Gasset once gave an interesting description when talking about technology and human desire: “Technology is what people go through to save energy!”[3]. When people are freed from the drudgery of labour, technology becomes a human “agent”. At the same time controlled and dominated by computer algorithms, smart wearables can also lead to a degradation of human cognitive and mobility abilities. The development of smart wearables is substantially changing people, and they are unwittingly becoming dependent on technology. Human beings will become increasingly dependent on technology and devices, and thus in some areas their ability to work independently will become weaker and weaker. In the context of a burgeoning smart economy, the trend is for productivity to soar and economies to expand. In the long run, in an intelligent economy and society, people with little technical skills are the weakest in the era of artificial intelligence. As production becomes more intelligent, industrial structures are upgraded and profit is driven, intelligent machines take over human jobs and are more capable of doing the tedious and heavy work. Under the logic of technology human labour is constantly suppressed or replaced by intelligent machines, labour opportunities and values are gradually lost, the labour division system is subject to unprecedented impact, technological unemployment becomes an inescapable social problem, and the risk of social stratification and social exclusion is thus constantly expanding. Therefore, the choice of smart wearable devices needs to be re-examined in a calm and rational manner.

4.3. Social life distortion and social interaction dilemmas

Neither the invention nor the application of technology can be separated from the practice of human social life, and without the application it is not a technology in the complete sense or a realistic technology[24]. On the one hand, the rational application of smart wearable devices has brought many conveniences to social life. In the smart elderly service based on medical health, the advantages of combining smart wearable devices can ease the pressure of elderly people and strengthen the health management of elderly groups. In the smart urban metro transportation service based on wearable technology, the innovation of wearable technology has changed the way people travel. On the other hand, we find that dependence on smart wearable devices is also inevitable in social life and social interactions. People are addicted to the fully intelligent experience and unprecedented convenience brought by smart wearable devices, and at the same time, to a certain extent, they begin to rely on machines and become technologically alienated by machine control. The essence of technological alienation is the alienation of the level of human cognition rather than the change of human status as a subject, which we can examine in terms of the excessive intervention of physical technology in the social life of human beings. In the context of the application of smart wearable devices, man's excessive attachment and dependence on the virtual world has caused human relationships to become alienated and distant. The various relationships between people and themselves are manifested through human relationships, and the realisation of relationships with others is corroborated through relationships of interaction[25]. Smart wearable devices open the door to real-world interactions and bring great convenience to human interactions. For example, the ability to identify a future partner with the help of a smart wearable device and to determine whether the "person in front of you" is the right person for you by wearing a pair of special glasses may seem efficient, but it seems to take away the fun of relationships. According to Alex Pentland, the father of smart wearables, the joy of falling in love cannot be taken away, and the art of falling in love lies in finding those interesting points that can be shared with the other person. One judges the other person by what they wear, where they grew up or their degree, etc. When choosing a life partner, does a person leave the decision to an intelligent machine or is he or she in the presence of a social interaction? It is clear that with the combined development of biotechnology and smart technology, smart devices with autonomous consciousness are "replacing human choice" and breaking the social logic of human social interaction. Smart wearables as a resource should serve people, not interfere with them, which must be guarded against. The original intention of man to create machines and devices was to make them tools that we could tame to our full technological advantage and creative capacity. However, in practice, it is becoming clear that the effectiveness of "intelligence" and "empowerment" is underpinned by a lot of uncertainty and uncertainty, blurring social life. Smart wearables are smart machines that "proxy" for real-world partners, friends and children, creating a distortion of social life and a crisis of social interaction. With the popularization and further application of smart wearable devices, we should think about how to dissolve the phenomena of the virtualization of human interaction, the virtualization of interaction objects and the destruction of interaction norms.

4.4. The deepening digital divide and the widening gap between rich and poor

The digital divide is the fourth major dichotomy after the urban-rural divide, the industrial-agricultural divide and the brain-body divide, and refers to the deep class divide in terms of effective use of the Internet and the skills needed to do so. The digital divide is also a technological divide, where the advantages of emerging technologies represented by the Internet are not shared equitably across regions and populations, potentially raising certain human rights issues and equity concerns. On the one hand, the application of wearable technology inevitably raises new issues of the digital divide, where the unconditioned are excluded from smart wearables due to varying levels of scientific literacy, technical ability and economic status, and inconsistent proficiency in mastering smart wearables across groups and countries, giving rise to asymmetries in individual rights. For example, organisations that rely on wearable technology and have a technological advantage can use the resulting data to judge and master the characteristics, interests and behaviours of their members by empowering them with vast data tags, even to the point where the onlooker knows more about the self than the self. In empowering users with data tags, technological asymmetries are created between the organisation and the user, thus creating a huge asymmetry of power. On the other hand, as technological systems and social structures become more and more highly complex, with vast amounts of information resources capable of being recognised and processed by intelligent computer software, the field of smart wearables is being reduced to a privileged playground for the economically and technologically powerful, and a digital economy emerges in the era of smart wearable technology where everything is connected. In many cases, smart wearables are used preferentially by those with higher social status, economic resources and good education, thus further widening the gap in access to social resources, wealth distribution and education levels. In the environment of the new wearables industry, digital possesses some economic value and dominates the appropriation of social wealth, with the digital elite monopolising key data resources to gain economic benefits, rather than relying on hard work. Wealth and power may be concentrated in the hands of a tiny elite with powerful algorithms, creating unprecedented social and political inequalities[26]. The digital divide has created a large group of "Digital Poor", contributing to social stratification and economic disparity between rich and poor. In fact, the data and algorithm-related applications involved in smart wearables may trigger a "horse-trading effect" where the poor get poorer and the rich get richer, thereby increasing social inequality and leading to social stratification and polarisation between rich and poor. While wearable technology provides consumers with humanised technological systems, it also makes the disadvantaged more vulnerable. As Mary Shelley[27] metaphorically stated in *Frankenstein*, Frankenstein's ability to help the masses with his extraordinary abilities shows the warm side of science and technology; he may also develop into a disruptor of the social order. Therefore, the future development of smart wearable devices should be humanistic enough to bridge the digital divide and the gap between the rich and the poor, so as to achieve the perfect leap from "wearable" for a few to "wearable" for all.

4.5. "Digital Leviathan" formation and public safety hazards

According to the British philosopher Thomas Hobbes[28], the "State Leviathan" is a behemoth that exists to protect the interests of the people and make their lives safer and better. In the context of a smart society, the state can use smart wearable devices to enhance its social surveillance capabilities and create a highly efficient "State Leviathan", but at the same time the function of these smart technologies in safeguarding the legitimate rights of citizens is more likely to be marginalised. The symbiotic structure of the state's surveillance system and civil rights protection mechanism is broken by the paradox of data technology brought about by the "digital leviathan"[29]. Therefore, the negative function of the "State Leviathan" should be curbed in time. With the use of new technologies such as Big Data, Artificial Intelligence and the Internet of Things, people are enjoying data as a key factor of production in society, while at the same time feeling a sense of "digital bondage" is also emerging. Digital technology as a means of restraint for the "State Leviathan" begins its alienation process and evolves into a new kind of leviathan–the "Digital Leviathan", which brings together the combined forces of technology and state power, thus generating effects and risks. The momentum of the formation of the "Digital Leviathan" has given rise to questions of information protection and public security. The "invasion" and "theft" of data by "out-of-body nature" wearable technology inevitably raises the question of public security in such technology. Data security is the foundation of national security, and as data is a core element of smart wearables and the Big Data era, its quality and computing power continues to increase, and how it is managed and used becomes an issue that cannot be ignored in the development of wearable technology. The rate of technological advancement in computing continues to increase and has been seen as a force unto itself[30]. This independent power will continue to "expand", but only in the context of public safety. In the era of intelligence, a hegemonic monopoly on technology will bring new threats to other countries and lead to the development of smart wearables in the wrong direction. The momentum, if not effectively controlled, will pose a threat to public security. The modern concept of public security is more focused on the human-centred dimension, which encompasses aspects from human physical health to psychological stability, from social security to national security. In the era of wearable technology, massive amounts of data and personal information are constantly being mined and utilised, and people are constantly providing information value when interacting with information. While information security is also under threat, it is particularly important that public safety risks in society are avoided.

5. Conclusions

Technology has always been a mixed blessing "gives us both creativity and destruction"[31]. The social risks resulting from the misuse of smart wearables go far beyond the above, as Anthony Giddens[32] argues that technological progress manifests itself as a positive force, but it does not always do so. The development of science and technology and the issue of risk are closely linked. In the long run, while smart wearables fulfil certain aspects of human needs, the security threats hidden within them also weigh on a person's ability to cope. While wearable technology brings us many positive values, it inevitably brings corresponding social risks. If smart wearables based on Big Data and algorithm-enabled devices are used illegally or maliciously, they can create unpredictable social risks and even lead to more serious risks of social fragmentation. There is no limit to the development of smart wearables that can be "used for good", but there should be a defined "threshold" of technological capabilities that can be "used for evil". The risk of alienation of smart wearables is not in itself terrible, but the question is whether we are aware of the risk that has crept up on us. The question is whether we are aware of the risk that has crept up on us. Further discussion is needed on how to further clarify the direction of wearable technology and its industry.

Conflict of interest

The authors declare no conflict of interest.

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REVIEW ARTICLE

Mobility aids for visually impaired persons: Journals reviewed

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ABSTRACT

This paper reviews the literature on mobile assistive devices for visual impaired people, in order to have a clear understanding of the technology and technological progress of helping visual impaired people. In this way, it aims to obtain basic guidelines for analyzing the most relevant equipment to help people with impaired vision and highlight the improvements that can be achieved. The most common device is to integrate different sensors and electronic components into the walking stick to improve their obstacle detection ability. In addition, equipment with cameras, including computer vision algorithms and artificial intelligence technology, has been developed to improve the performance and efficiency of the equipment. Finally, the basic characteristics of the auxiliary system are introduced, and it is found that there is no equipment to meet the needs of users.

Keywords: visual impairment; assistive technology; computer vision; artificial intelligence

1. Introduction

Around the world, 39 million people are completely blind and 246 million have low vision, of which 285 million have visual impairment. More than half of the population is over 50 years old and lives in poverty. Uncorrected ametropia and cataract are the two most common causes of visual impairment, as shown in the **Figure 1**. Percentage of major diseases leading to blindness worldwide[1].

In a study based on 15 surveys in Latin American countries, 0.9% to 2.2% of the population over the age of 50 had functional visual impairment. The main causes of low vision were age-related macular degeneration (26%), glaucoma (23%), diabetic retinopathy (19%), other posterior segment diseases (15%), corneal opacity (7%) and complications of cataract surgery (4%). According to statistics, about 4,000 people per million people need low vision functional services[2].

Throughout Colombia, an estimated 7,000 people (more than 296,000) are blind for every 1 million people. These figures apply to all the population in the country. Although they have a greater negative impact on children’s learning and maladjustment, it is found that about 2% of children aged 6 to 11 have vision less than 20/60, and 75% use special lenses for correction, indicating that the causes of ametropia and visual impairment are the largest and can be corrected in a certain proportion, using

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the appropriate optical equation[3].

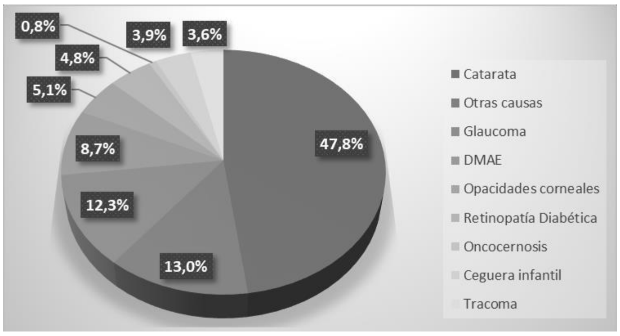

Figure 1. The number of major causes of blindness in the world.

The World Health Organization (WHO) estimates that blindness and severe visual disability will become public health problems worldwide by 2020. This situation will create a general social, economic and cultural burden, especially in low- and middle-income countries[1]. Although it helps to improve the residual vision of people with mild to moderate visual impairment, they are not suitable for people with severe to severe visual impairment (DVS, DVP) or blindness, who need to develop alternative vision skills[4]. It is more difficult for them to achieve independence in the basic and instrumental activities of daily life, because other types of disabilities may coexist, further limiting this process.

People with impaired vision rely heavily on others or certain tools to move safely in an unknown environment. In general, they rely on tools such as walking sticks or guide dogs, and each aid has its own limitations. The range of crutches is about 1.5 meters and is not used to detect obstacles above the waist. In the case of guide dogs, it takes a long time to train dogs, and there is also an additional time to adapt to these people and their proper care is difficult visual impairment[5].

Visual impairment has a great impact on an individual's quality of life, including the ability to work and develop interpersonal relationships. Loss of vision causes individuals to lose about 90% of their spatial perception. Nearly half of the visually impaired feel completely alienated or alienated from the people and things around them. In order for visually impaired people to truly integrate into society, it is necessary to eliminate the possible physical, technical and mental barriers due to their disabilities, because, like any citizen, they play a social role by developing their personal skills and abilities[6].

Recent technological advances aim to help and improve the quality of life of visually impaired people and improve their independence in daily activities. Electronic equipment based on various sensors integrated on the walking stick to improve the effectiveness of obstacle detection and spatial perception of the disabled, camera system with computer vision algorithm, and the implementation of artificial intelligence (IA) technology for text reading, face recognition, etc. They are the main technology for visually impaired people[7,8].

Technological progress is not plain sailing. In a world with the next major development every minute, mainly in the field of software and mobile devices, people with certain visual impairment have been excluded. However, some innovative tools try to take advantage of the potential of new technologies to make their lives easier[9]. This paper reviews various technical projects developed in recent years to help the visually impaired move and navigate autonomously.

The methodology and structure of this review document include the following steps: Chapter 2 provides a background introduction to the definition of assistance technology, especially for people with visual disabilities. Then, in Chapter 3, academic and research literature sources are searched through special engineering databases (mainly IEEE and science direct) and academic meta search engines (mainly Google scholars and semantic scholars). The latter produced results from various sources and required special consultation. In this step, we only select articles that help or propose innovations, concepts or developments that can be reflected in the impact of visually impaired people on daily activity performance, in order to find the most relevant characteristics that affect such assistance. Subsequently, this information is abstracted and divided into different technology affinities in order to deal with topics that can classify the discovered technologies. Chapter 4 summarizes the research results to determine the possible work routes and specific conditions required to develop future equipment for this assistance mission. Finally, the fifth chapter gives the conclusion.

2. Technical assistance

According to the European Council of optometry and optics[10], low vision refers to abnormal vision, which hinders the ability of daily work. This situation cannot be corrected by optical equation or medical intervention. Typical symptoms of vision abnormalities include loss of vision and field of vision, loss of contrast sensitivity, nocturnal mink, color recognition problems, and increased sensitivity to light (such as glare or photophobia). On the other hand, the international code of diseases (ICD-10) defines blindness as "vision less than 0.05 (20/400, 3/60, 1.3 logmar), or the corresponding visual field loss in the best corrected eye is less than 10 degrees". Finally, severe visual disabilities include vision less than 20/200, 6/60 and equal to or higher than 20/400 or 3/60, and for mild visual disabilities, vision between 20/60 or 6/18 and 20/200 or 6/60[11].

Autonomous orientation and autonomous movement are activities directly related to vision. Therefore, the difficulty of movement of people with visual impairment has become the most common problem in their daily activities. That is why it is essential that these people use the equipment and technology to help them develop their daily lives[12]. The most commonly used tool for people with visual impairment is the white cane, which can guide them to move autonomously in different places. It has three basic characteristics: Uniqueness, protection and information[13]. Some of the latest efforts in assistive technology for visually impaired people are aimed at providing electronic devices to adapt to mobile and travel tasks to promote them[14].

2.1. Electronic auxiliary equipment integrated in walking stick

Assistive technology is any improved equipment or system used to improve the functional ability of some people with functional disabilities[15]. For people with low vision, electronic crutches with ultrasonic sensors have been developed to detect nearby obstacles in advance.

Use the following keywords and equations to query in the database and meta search engine:

- Sugarcane and electronic assistance
- Sugar cane and technical assistance
- Visual impairment and electronic crutches
- Ultrasound and visual impairment
- Smart crutches and electronic help.

According to the emission of ultrasonic pulse and the measurement of the time difference between acoustic emission and echo reception, the distance of obstacles generating acoustic reflection can be determined[16–18]. These devices provide audible or vibration alarms to prevent users from approaching objects, and similar developments and structural changes have been found in the implementation of proximity sensors[19], which are adjusted by replacing sensors on walking sticks with elements such as hats and vests under the same principle. Different applications propose to increase the functions of these devices by using a series of technologies, including infrared sensors to detect horizontal changes on irregular ground, GPS (Global Positioning System), GMCS (Global Mobile Communication System), GPRS (General Packet Radio Service) to locate people, locate them in a specific position or guide them to a specific direction, RFID (radio frequency identification) is used to improve navigation in areas with different tags, strategic locations, etc. Finally, according to the needs of the application, various technologies and tools are integrated to improve the action and positioning assistance of people with visual impairment[20,21].

One of the most important projects related to the implementation of electronic components and sensors is the intelligent sugarcane product, which is designed to detect objects on the road and generate direction indications[22]. Smart sugarcane is a portable device with ultrasonic sensor system, humidity sensor, microcontroller, a series of motors and buzzer, which is used to detect obstacles in front of users and provide indication through handheld audio message or vibration alarm. Most electronic devices developed to help visually impaired people rely on information obtained from the environment, and data is transmitted to users through audio devices or vibration alarms. People have different views on what is the best type of feedback, although it is still a discussion topic that can only be solved by end users of different implementation systems.

Mobile enabled electronic devices have not been very successful in business because it is difficult to compete with simple and low-cost walking sticks. What proves this is that many of these devices have been sold on the market and are no longer on the market[23]. These sensors based mobile auxiliary devices are used to detect nearby obstacles, and there are some design defects. The most important is the communication interface, which sends sparse information to the user without specifying the type of object to be detected, and may represent danger.

2.2. Support of artificial vision algorithm

Artificial vision is a subject that aims to simulate the different processes and elements given to machine vision. These include geometric and other attributes such as color, lighting, texture, and composition. Vision, a person and a computer. This subject mainly includes two stages: Acquiring images and interpreting images. The image acquisition process is carried out by camera. In this way, it only needs subtraction implementation tools to interpret the image, distinguish the objects in the scene, extract information from it, and solve more specific problems as needed[24,25].

As an alternative to human vision, computer vision is a key tool to realize the support equipment for visual impairment. Artificial vision is used to support some of the main tasks of visually impaired people, including assisting in movement, orientation, object recognition, obtaining printed information and social interaction. Unlike the technology that combines electronic devices and sensors, artificial vision allows interpretation of the environment and provides a higher degree of realistic representation from more complex information processing. In recent years, the use of artificial vision has been extended to support these[26,28] laptop based prototypes.

In recent years, the integration of digital cameras into smart phones has created a new generation of tools that enable these people to perform daily tasks, such as obstacle detection[29], reading printed matter[30], identifying common objects in supermarkets[31,32], spatial positioning indoors or outdoors[33], and social interaction with people around them[34].

Use the following keywords and formulas to query in the database and meta search engine:

- Computer vision and assistive technology
- Computer vision and visual impairment
- Digital image processing and visual impairment

An example of a real-time obstacle detection system based on artificial vision algorithm is given in[35], which is used for obstacle detection and movement assistance for indoor and outdoor visual obstacles. The application works with the help of a mobile device with a camera. The device can detect static and dynamic objects in video sequences. The implementation of the system on smart phones has provided great help for the actions of people with visual impairment, because smart phones are more and more portable and have stronger processing ability. However, in places with low illumination and frequent movement, target detection can not be detected effectively. In addition, the results of the application can vary significantly according to the quality of the video that can be obtained by the camera of the mobile phone.

Although artificial vision has become a widely used tool for developing assistive technology for people with visual disabilities, with the emergence of high-capacity processors and the development of current hardware, the ability to implement algorithms in software has not been brought into full play[36]. A common problem in the development of new technologies is that in this case, they are not designed according to people's specific needs. Therefore, the real needs of users are unknown, resulting in the failure of the developed equipment to obtain the expected results. Another important problem is that these devices are bulky and difficult to use.

2.3. Computer vision and artificial neural network (RNA) are combined as auxiliary means

The concept of artificial intelligence may have different meanings, depending on its source and viewpoint. Obviously, one of the goals of artificial intelligence is to study the intelligent behavior of machines[37]. In other words, artificial intelligence studies how to make computers do the best things that human beings do at present.

Neural network is established in the motion research of artificial intelligence.

With the increasing possibility of machines helping human beings' complete daily tasks, some of the most common tasks include: Pattern recognition, character recognition, speech recognition, face recognition, facial expression recognition, planning different tasks, etc. In a 1950 article entitled "computing machines and intelligence", Alan Turing wanted to know whether machines can think[39]. To get closer to the answer, he proposed a test called Turing test to determine whether machines can simulate human dialogue, "Users who talk through written channels must determine whether their interlocutor is a human or a machine"[40].

One of the biggest challenges facing mankind is to understand the function of the senses, and then imitate this function through the existing technology, so as to find ways to solve the problems in the real world[41]. This method uses different computer vision algorithms for image processing, and artificial intelligence technology for data analysis and final results.

Use the following keywords and formulas to query in the database and meta search engine:

- Neural network and auxiliary technology

- Artificial neural network and visual impairment

- Artificial intelligence and visual impairment

Various applications to help visually impaired people integrate the use of RNA trained systems and the use of cameras to obtain images for pattern recognition[42,43]. Detect different types of objects, such as doors, corners, edges, paths, etc. These objects help to identify obstacles[44,46] and recognize faces and facial expressions to improve social interaction[47].

2.4. Use deep learning to assist the image classification process

Machine learning is actually a set of technologies that make artificial intelligence part of algorithm-based learning in large data sets. A very important feature of these algorithms is to predict new cases based on the experience learned from the data set used for training[48].

Deep learning (DL) is a branch of machine learning. It contains a series of algorithms to simulate the execution process of brain neurons to perform voice, image, word and other applications. These algorithms are processed in layers. Each layer has neurons. They simply process the output of the neurons in the previous layer. However, it is inappropriate to make an analogy with the structure in the real brain, because artificial neurons are much simpler than natural neurons. It can be assumed that artificial neural networks constitute mathematical models similar to natural networks, and they perform useful functions because they can adapt or learn in a sense[49]. Deep learning is a concept derived from the idea of using hardware and software to simulate the brain, using hierarchical abstraction capabilities (i.e. Multi-layer representation of input data) to create artificial intelligence[50]. Since then, the number of structures and training algorithms has increased rapidly[51].

In order to realize DL, we especially use a structure close to the distribution of biological nervous system, in which a group of artificial neurons are responsible for detecting some features of objects in the image. The application of combined artificial vision algorithm is one of the fields where DL has significant improvement over traditional technology.

Use the following keywords and equations to query in the database and meta search engine:

- In depth learning and technical assistance
- Convolutional neural network and visual impairment
- Object detection and automatic and visual impairment
- Image classification and technical assistance

DL algorithm has become a new choice for developing systems. These systems allow to recognize body expressions, classify images from large databases[52,53], and realize mobile robot obstacle avoidance. Its algorithm and working principle can be applied to help people with impaired vision move independently. Detection and avoidance of targets[54,55] and classification and classification of obstacles[56].

3. Analysis

The number of references found in each topic defined in the previous chapter illustrates the historical development of each topic **Figure 2**. Therefore, it is believed that the fastest-growing theme is 43% of electronic assistive devices, which may be because it is a technology that has existed for decades. For example, compared with artificial vision, it has hardly had any significant development and research in recent decades.

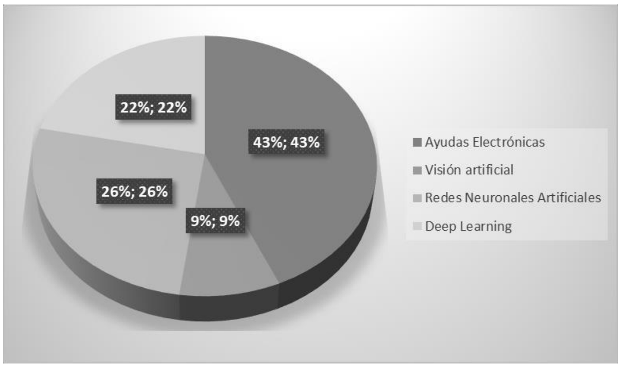

Figure 2. Percentage of references found in each topic.

Various visual impairment AIDS shall provide a series of functions to ensure their user assistance functions. These functions correspond to clear and simple user feedback interface and correct performance under different environments and lighting conditions, it can detect static and dynamic objects to analyze any sudden obstacles on the road, and integrate software and hardware with appropriate performance to process data. These functions are the basic and key to the design and implementation of visual impairment AIDS, because each function will have a significant impact on team performance.

According to the basic characteristics defined and the needs of users for mobile support, no application found shows completely satisfactory performance. It is worth noting that each developed prototype has special functions and may have additional functions, but no prototype supports all necessary functions, which are regarded as comprehensive services to help the visually impaired. This means that it is impossible to regard any development as an ideal device. The main reason for these limitations is that most developers and researchers focus on implementing a different technology to provide a new function, but they don’ t notice that their work recognizes the basic functions before adding new functions. The purpose is to create more innovative devices from an academic perspective, rather than as functional elements of user support and services. Another reason for these limitations is that designers do not conduct sufficient research to clearly and concisely determine people' s basic views and requirements for a system that will help them in their daily life activities.

4. Conclusions

Countries around the world have made different development and research in solving the problem of visual impairment. Despite efforts, it has not been possible to integrate appropriate tools to provide reliable assistance to meet the main needs of these populations.

In order to develop a device to help people with disabilities move, it is necessary to classify the main needs of people with disabilities, because the environment provides a lot of information and electronic devices have processing capacity. This research is crucial before determining the technical characteristics of auxiliary equipment.

Using artificial intelligence technology and computer vision tools, we must realize the integration of hardware and software to make object classification and obstacle detection possible, analyze it in real-time video, and generate possible auditory alarms for users according to the preset hierarchical order.

Conflict of interest

The authors declare no conflict of interest.

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REVIEW ARTICLE

Research progress on wearable devices for daily human health management

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ABSTRACT

As the public's demand for portable access to personal health information continues to expand, wearable devices are not only widely used in clinical practice, but also gradually applied to the daily health management of ordinary families due to their intelligence, miniaturization, and portability. This paper searches the literature of wearable devices through PubMed and CNKI databases, classifies them according to the different functions realized by wearable devices, and briefly describes the algorithms and specific analysis methods of their applications and made a prospect of its development trend in the field of human health.

Keywords: wearable device; physiological signal; algorithm; sensor; health management

1. Introduction

Wearable devices, also known as wearable biosensors, can collect the original physiological parameters of the population, and then process them into health digital information that users can easily understand for health monitoring, such as heart rate, blood pressure, blood oxygen saturation, blood sugar and continuous monitoring of body temperature, etc. At the same time, the wearable device can also collect related indicators such as steps, activity category, posture, activity trajectory, sleep monitoring and energy consumption. Wear it on different parts of the human body according to the needs of users and the functions achieved by the device. The common wearing position and information transmission and storage process are shown in **Figure 1**. Compared with the early wearable devices, the wearable devices in recent years have been more lightweight, refined and fashionable in design. At the same time, as people's demand for mobile health increases, higher requirements are also placed on the performance of wearable devices. In order to better understand the application status of different wearable devices in health-related fields, this paper adopts the literature tracking method, and uses the PubMed and CNKI databases to search the literature in the past ten years using the keyword "wearable device". Since this paper only studies the application of wearable devices in the field of human health, research in the fields of industry, education and military is excluded. The searched documents are classified by the application fields of wearable devices involved in the literature and the

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specific sensors and related algorithms used by the devices and summarises the relevant key technologies involved in the daily application of wearable devices, analyzes its possible problems, and summarizes the development trend of smart wearable devices in the field of human health.

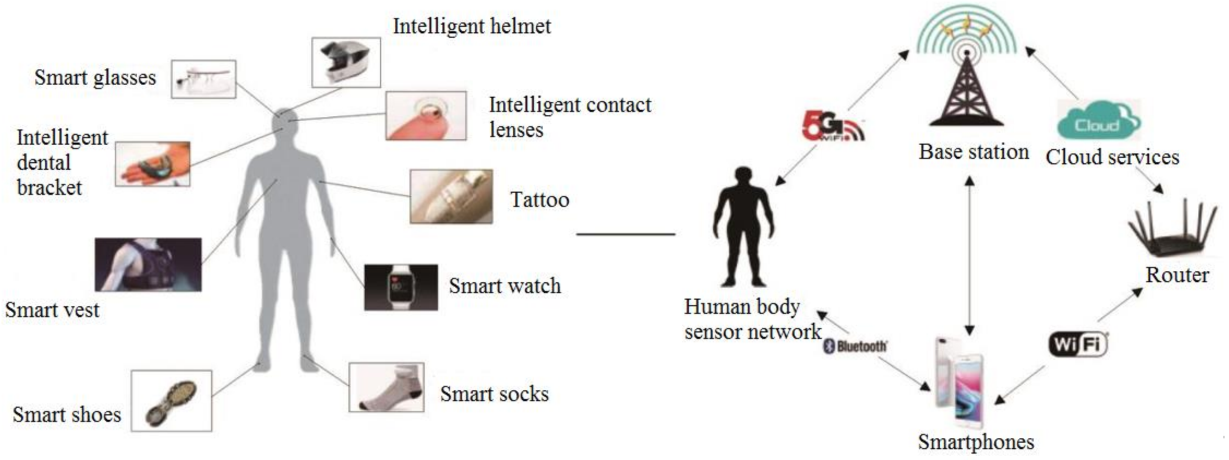

Figure 1. Flow chart of common wearing positions and data transmission and storage of wearable devices.

2. Application Status

This paper uses the PubMed database to search the literature in the past ten years using the keyword “wearable device”, a total of 552 literature (excluding 908 review literature), through the statistical summary of the wearable devices used in the literature, according to the wearable device. The functions and application fields realized by wearable devices can be divided into the following categories.

2.1. Entertainment and leisure

Products such as smart glasses, wireless headsets and VR helmets are typical leisure and entertainment wearable devices, which occupy most of the wearable device market. In addition to the beautiful appearance, its core technology mainly lays in the battery life of the device, wireless communication technology and human-computer interaction effects. Generally, such wearable devices will combine multimedia applications such as cameras, videos, and music, and are mainly used for users to browse pictures, web pages, etc., and typical commercial products such as Google glass, Baidu Eye, Emotiv helmet, Apple watch, etc.

2.2. Motion detection class

Most sports detection wearable devices have built-in barometers, three-axis acceleration sensors and gyroscopes, which can detect the number of steps, distance, calorie consumption, activity type and posture during exercise. Due to the great instability of the signal during the movement, the sensitivity of the sensor and the accuracy of the algorithm have high requirements. Commercial wearable devices using different sensors are becoming more and more widely used, and the hottest one is in the field of motion analysis and activity monitoring of inertial measurement devices[1]. Generally speaking, the filter, peak and valley detection and frequency domain adaptive threshold functions of sports wearable devices can make the device show strong stability for different users and environments. However, in most cases, few researchers have established a mathematical model of the relationship between sensor signals and activity detections.

Step count

Step counting is the basic function of motion detection wearable devices, and the step counting function is mainly realised based on MEMS. Common step-counting detection algorithms mainly include peak detection algorithm[2], dynamic threshold detection algorithm, zero-rate correction algorithm, autocorrelation algorithm and combination of two or more algorithms. Other time- and frequency-based methods, such as fourier transform and wavelet transform, can utilize the walking cycle to achieve accurate step size detection. Studies have shown that commercial fitness wearable devices are less accurate in evaluating activity intensity than research-grade accelerometers[3]. Winfree et al.[4] evaluated Fitbit and found that Fitbit's assessment of exercise intensity has a low accuracy rate. The team also used Actiongraph GT3X algorithm combined with Bayesian classifier to improve Fitbit Flex, reducing the error rate to 16.32%. Tao et al.[5] made a review on a variety of pedometer APPs based on the Android system. The results show that the accuracy of step counting function of fitness APP is related to the actual walking speed and device placement. In general, a pedometer worn on the hip or foot is more accurate than a pedometer worn on the wrist or measured with a smart phone. Toth et al.[6] conducted a comparative analysis of 8 pedometers on the market (StepWatch, ActiPAL, Fitbit Zip, Yamax Digi-Walker SW-200, New Living Style NL-2000, Actiongraph GT9X, Fitbit Charge and Fitbit AG) using 14 different pedometer methods, and found that StepWatch has the highest pedometer accuracy. Various calibration methods can be used to improve the accuracy of the pedometer function of wearable devices, such as personalizing settings based on a single user and detecting the minimum walking duration before activating the pedometer function[7].

Energy expenditure

The functions of wearable devices are gradually diversified, and calorie consumption is one of the focuses of consumers. Generally speaking, the measurement of energy expenditure (EE) includes direct measurement method and indirect measurement method, which can be represented by oxygen calorific value, respiration entropy, etc., and different formulas are used to calculate EE according to body mass, exercise time, speed, distance, etc. Among them, the double-labeled water method and the gas metabolism analysis method are called the "gold standard" for evaluating EE, but they are both expensive and inapplicable. Health-related smart wearable devices mostly use MotionX technology, which uses 3D accelerometers to identify motion patterns and convert them into identifiable energy consumption[8].

Currently, there is no single technique that can accurately quantify EE under free-living conditions, but multiple methods can be combined to improve accuracy, such as heart rate, acceleration measurements, and step counts. Pande et al.[9] developed an initial linear regression model based on neural network and bagging regression tree, and the correlation between the EE measured by the barometer data and the actual EE measured by the gold standard calorimeter (COSMED K4b2) can reach 96%. Shcherbina et al.[10] selected 60 volunteers to accept the evaluation of 7 devices in different states. The experiment showed that Apple Watch 3 had the lowest overall error rate, Samsung gear S2 has a high error rate, all devices have an error rate of more than 20%. Most wrist-worn devices perform poorly on EE measurements during laboratory activities. The device is poor in measuring EE during laboratory activities. Some researchers compared three commercial sports watches (Suinto Ambit2, Garmin Forerunner920XT and Polar V800), and found that the calculation accuracy of the EE value of the device depends on the exercise intensity, and the error rate of the three devices is higher under high-intensity exercise[11]. The accuracy of outdoor activity EE detection using wearable devices is still low, and more effective motion detection sensors and algorithms need to be developed[12].

Activity track and motion classification

Human activity recognition systems can be roughly divided into two categories: (1) Systems based on computer vision; (2) systems based on acceleration sensors[13]. Various sensors can be used to improve the performance of the recognition system, such as RGB sensors, depth sensors (Kinect, etc.), and inertial sensors. Traditional motion recognition mainly follows the pattern shown in **Figure 2**[1].

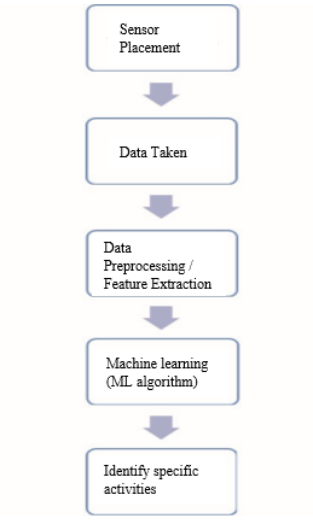

Figure 2. Traditional motion recognition development system.

Mooney et al.[14] evaluated two devices, Finis Swimsense® and Garmin Swim™, The algorithms of both devices can accurately assess different strokes, but there are individual differences in accuracy (professional athletes have higher accuracy than amateurs). Kanoga's team[15] used the EMG control system to identify motion through surface EMG, and found that compared with the traditional motion recognition algorithm, the armband-type surface EMG device has stronger performance for short-term use, but it is not suitable for long-term use. Commercial smart wearable devices mostly use GPS sensors to realize the positioning function, cooperate with three-axis sensors to realize the identification of different motion modes (climbing, walking, cycling, etc.), and use third-party applications to display dynamic motion trajectories in real time.

2.3. Human health monitoring and medical applications

Wearable devices can not only provide short-term physiological data, but also realize long-term and continuous human monitoring under different conditions, which can provide a certain basis for clinical decision-making[16,17]. Jovanov[18] found that 10 patients with chronic diseases who were intervened by wearable health monitoring devices had a significant decrease in average weight after 3 months, and their physical activity level and health status were significantly improved. Voss et al.[19] used Google glass to intervene in children with autism spectrum disorders, and taught children to recognize and express emotions through interventions such as pictures and audio from wearable devices. Clinical studies have found that wearable device-guided digital home therapy can improve current levels of care.

Sleep monitoring

In general, polysomnography (PSG) is used as the gold standard for assessing sleep, but it is only suitable for clinical and laboratory research settings and requires professional operation. Actigraph is generally used in non-lab environment; this device can be worn all day, converts the collected physiological signals into digital signals and exports them through a three-axis accelerometer, etc. However, Actigraph has certain defects and cannot identify the sense of motion in a static state[20].

Gautam et al.[21] classified the human body data collected by the built-in accelerometer of smart-phones based on the Kushida algorithm, statistical functions and hidden Markov models, and differentiated between sleep and wakefulness. Meltzer et al.[22] evaluated the sleep monitoring effect of Fitbit Ultra in 63 adolescents and children. The experiment proved that compared with PSG, Fitbit Ultra overestimated the total sleep time and sleep efficiency in normal mode, and the opposite in sensitive mode. Therefore, in clinical practice, this device cannot replace traditional PSG and needs to be used with caution. Xie et al.[23] conducted a variety of functional evaluations on the best-selling and best-reviewed products on the market through a meta-analysis. In terms of sleep monitoring, these wearable devices achieved relatively high accuracy, with an average absolute percentage error of 0.11 and the difference between different devices is small. Previous studies have found that only using motion sensors to identify sleep states will produce large errors, and it is easy to classify resting and awake states as sleep states. Therefore, it is recommended to use multiple sensors to detect sleep. The introduction of new algorithms and parameters to evaluate sleep states may have better results[20].

Atrial fibrillation detection

Atrial fibrillation is the most common arrhythmia disease, and is prone to complications such as arterial embolism, pulmonary embolism, cardiac insufficiency, and sudden cardiac death. Therefore, early prediction and timely treatment of atrial fibrillation are of great significance in reducing the incidence of stroke and other vascular embolic diseases[24].

Common atrial fibrillation detection devices are mainly clinical ECG, implantable ECG equipment and portable wearable ECG measurement device. Photoplethysmography (PPG) is the most common wearable technology used to detect cardiac function. Usually, the data from the PPG sensor is processed by the beat frequency detection algorithm, which generally includes data pre-processing, waveform extraction, peak and valley detection, and the classification of the interval between beats[25]. A new framework was proposed to distinguish atrial fibrillation from other types of heartbeats by combining an improved frequency slice wavelet transform with a convolutional neural network, confirming that it is possible to accurately identify atrial fibrillation from short-term signals[26]. There is also a portable ECG measurement device used in conjunction with ECG equipment. Fan et al.[27] used the “palm ECG” E-U08 device to remotely monitor the patient’s ECG outside the hospital and feed it back to the doctors in the hospital in real time. The detection rate is significantly higher than that of traditional 12-lead ECGs. William et al.[28] compared the Cartier mobile heart monitor with lead ECG in 52 patients, and confirmed that clinicians could improve the accuracy and efficiency of atrial fibrillation detection with the aid of equipment. The Kardia Band (KB), the first approved smart-watch accessory released by AliveCor, detects atrial fibrillation by recording single-lead ECG signals[29], and later released the Kardia Mobile 6L ECG device that can use six leads. The Study Watch can record, store and display ECG waveforms, but this watch can only be used for laboratory research and cannot provide user data access[30].

Atrial fibrillation is a serious arrhythmia phenomenon, accompanied by various complications, and is the main cause of various heart diseases such as myocardial infarction. Atrial fibrillation is a serious arrhythmia phenomenon, accompanied by a variety of complications, is the main cause of myocardial infarction and other heart diseases, in order to realize automatic atrial fibrillation detection in small wearable devices, sophisticated sensors and algorithms are required, and the technical requirements are relatively high.

Fall detection

Identifying falls and initiating early warning can effectively reduce related morbidity and mortality. Clinical testing is limited in time and space, and the equipment used is cumbersome. The fall detection function implemented by wearable devices is not prone to signal errors in practical applications, and is the most practical.

General wearable devices are mostly based on three-axis devices such as accelerometers, gyroscopes and magnetometers, as well as multi-sensor fusion detection and video-based detection. Some studies have used machine learning methods to distinguish falls from normal states. Commonly used methods include k-NN, least squares, support vector machines, Bayesian decision-making, dynamic time warping, and artificial neural networks[31]. There are also studies using statistical analysis to extract signal features to identify fall trends. Generally speaking, the risk of falling has individual differences, which has a great relationship with age, body weight, etc., and the environment in which it is located also has a great influence on it.

Analysis methods based on biomechanical models need to extract specific features, and the final model performance depends on the specific model structure and input data. Aicha et al.[32] compared the traditional biomechanical model and its proposed deep learning neural network model, and found that the latter’s fall risk prediction accuracy was significantly higher.

In addition to the type and number of sensors, the placement of the sensors also has a great impact on the detection effect. The Özdemir group[33] summarized the number of sensors, subjects, sensor placement, sensor combination, classification algorithm and performance, the study found that simply reducing the number of sensors will reduce the detection accuracy, and the sensor using the k-NN algorithm is placed at the waist to achieve a sensitivity of 99.96%.

Blood sugar test

Diabetes is usually diagnosed and managed by continuous glucose monitoring (CGM) equipment. CGM can effectively control blood sugar and reduce insulin dosage in patients with type 2 diabetes mellitus[34]. In general, CGM provides input to a mathematical model that predicts fluctuations in blood glucose concentration over time. This algorithm relies on input from factors such as dietary intake, activity, and emotion that affect glucose metabolism, but is based on deep learning and support vector machines. The method can disregard these inputs and can predict the blood glucose change in patients with type 1 and type 2 diabetes for 60 minutes[35,36]. Bonn et al.[37] found that the intervention of the smart-phone APP combined with the GTX3X human exercise energy monitoring instrument in patients with type 2 diabetes can significantly improve the patient's exercise volume and glucose and lipid metabolism indicators. Mhaskar et al.[38] used deep neural network to evaluate blood glucose in groups, and the results showed that compared with shallow network, the detection effect of deep neural network was better. There are few products for wearable devices to detect blood sugar, which is still an area to be studied and explored.

3. Key technologies

There are many kinds of wearable devices on the market, and the realization of different functions depends on different technical support, such as the sensors used in the device itself, external data receiving equipment, wireless communication technology and data storage platform.

The sensors used in wearable devices are mainly divided into motion transmission sensors, biological sensors and environmental sensors, including gyroscopes, accelerometers, magnetometers, photoelectric sensors, barometric altimeters, and temperature sensors. Its human-computer interaction is different from ordinary smart devices. It is a direct and sufficient interaction method, mainly including voice interaction, tactile interaction, and consciousness interaction. At the same time, because wearable devices involve a wide range of fields, large amounts of data, and diverse application groups, it is necessary to use artificial intelligence to optimize the devices and platforms. Wireless communication technology is the link between users and devices, enabling data communication and information sharing between users, between users and devices, and between devices. Commonly used communication technologies now mainly include near field communication technology, Bluetooth and wireless network technology. Users can transmit data to the cloud platform for subsequent viewing, use and sharing through wireless communication technology with low energy consumption. Compared with the traditional human-computer interaction mode, the application of virtual reality and augmented reality in the wearable field pays more attention to the actual feeling of human senses. The way to obtain information is no longer limited by time and space, and virtual screens may become a visual supplement for human-computer interaction.

4. Conclusions

Most of the traditional wearable devices are devices based on research institutions or medical places guided by special personnel, providing real-time visual physiological data for specific users. As people pay more attention to health, the concept of smart medical care is more deeply rooted in the hearts of the people. Due to the limited medical resources, wearable devices also mean the transformation to the field of individual medical applications. It must develop in the direction of more informatization, digitization and intelligence[39]. Due to the development of technologies such as sensors, external data receiving devices, wireless communication technology and data storage platforms used in the device itself, in addition to the ordinary motion detection function, most smart wearable devices currently have certain human health management functions and the reliability of the detection data is high.

However, the popularization of smart wearable devices still faces a series of problems and challenges (**Table 1**). The development of Internet technology has made people not only have high requirements for device signal reliability, long-term stability and comfort, but also require data. There is also more attention to privacy protection, and it is necessary to continuously improve the algorithms for processing signals and analyzing data[42,43].

Table 1. The application status of wearable devices

Application field	Key Technology	Problem exists	Possible solution
Motion and attitude change detection	Three-axis accelerometer	Different devices have large differences in detection accuracy and poor device sensitivity; commercial devices are less effective than research-level devices	Consider machine learning, unified calibration methods, etc.
Energy estimation	Algorithms for resting energy expenditure and active energy expenditure	There is currently no single technique that perfectly quantifies the energy expenditure associated with physical activity under free-living conditions	Various complementary methods are recommended (heart rate, accelerometer measurements, pedometer-measured steps, etc.)[39]
Cardiovascular disease detection	photoelectric sensor	There are a lot of false positive events	Rhythm detection technology[40], etc.
Fall detection	Three-axis accelerometer	The accuracy is not high in real-life scenarios	Consider algorithm improvements[41] (k-NN classifier, least squares, etc.); Consider device wearing position (waist, ankle, etc.)
Sleep monitoring	motion sensor	There is a large error in distinguishing sleep states	Use multi-sensor detection

Most wearable devices are not very independent, and need corresponding terminal APP support. At the same time, the portable characteristics also require the miniaturization and integration of the sensors of the wearable device, and also require the device to have a certain battery life. Due to different application fields, there is still a lack of unified standards for general smart wearable devices. Although there are many types of wearable devices on the market with complex functions, however, there is still a lot of controversy about the application of special groups (the elderly, children and pregnant women, etc.).

Although there are many challenges, the development of portable smart wearable devices has become a major trend. With the development of technology, the hardware technology of the device (processor, battery technology, etc.), software system (user-centric more accurate algorithms, etc.), cloud services (personalized services, etc.) will achieve a certain degree of performance improvement, and the user experience will also be significantly enhanced. At the same time, with the development of 5G technology[44], the application of communication Internet technology will be more in-depth, providing technical supplements for the scarce medical resources in the post-epidemic era.

This trend will promote the cross-integration of expertise in more fields, promote the coordinated development of various industries, and will also create a healthier and safer application environment for smart wearable devices.

Conflict of interest

The authors declare no conflict of interest.

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REVIEW ARTICLE

Ventricular assist device for advanced heart failure

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ABSTRACT

Heart failure (HF) continues to be a highly prevalent disease, affecting 1–2% of the population in developed countries, therefore constitutes a health problem due to its high cost. Despite the progress made in drug treatment and implantation devices, the prognosis is poor. About 5% of patients diagnosed with heart failure are in advanced stage or stage D. Heart transplantation (HT) has become the preferred treatment for this high-risk group in the past 30 years. Unfortunately, in addition to the limitation of the current shortage of donors, there is only a limited number of patients meet the appropriate age and with the absence of comorbidities necessary to access this treatment. Due to this and the long waiting lists worldwide, the development and use of ventricular assist devices (VAD) are increasing. In view of the quality of life of patients with this serious disease, these devices improve the short-term and long-term survival rate and gradually reduce the complication rate. These benefits not only provide a choice for patients waiting for HT, but also give those with reversible contraindications the time and opportunity to become suitable candidates or, if impossible, eventually use it as a target treatment. However, these devices have many limitations: their cost, durability, incidence of complications and their limited application. Technological advances in mitigating complications, increased experience in management centers and their promotion to reduce costs are strategies that will continue to strengthen the use of VAD in patients with advanced heart failure.

Keywords: ventricular assist device; heart failure; heart transplantation; mechanical circulatory support; complications

1. Introduction

Heart failure (HF) is still a disease with high incidence, affecting 1–2% of the population in developed countries, so it is a health problem because of its high cost[1]. Despite the progress made in drug treatment and implantation devices, the prognosis is poor. About 5% of patients diagnosed with heart failure are in the late stage or stage D[2].

Advanced HF is currently defined as[3]:

Presence of symptoms at rest or with minimal exertion, function class (FC) grade III-IV according to the New York Heart Association (NYHA). Clinical evidence compatible with systemic hyperemia and/or hypoperfusion. Severe cardiac insufficiency: Left ventricular ejection fraction (LVEF) <30%. Doppler echocardiogram with pseudonormal or restrictive pattern in the mitral flowgram. Left filling pressure increased: Pulmonary artery occlusion

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pressure >16 mm Hg and/or right atrial pressure (RA) >12 mm Hg. Increase natriuretic peptide in the absence of noncardiac causes. Severe functional damage: Exercise intolerance. 6-minute walk test <300 meters. Peak oxygen consumption <12–14 ml/kg/min. Hospitalization history of decompensated heart failure in the past 6 months. Despite the best drug therapy and cardiac resynchronization therapy, all previous criteria exist.

In the past three decades, heart transplantation has become the preferred treatment for this high-risk group. Unfortunately, a small percentage of patients meet the appropriate age and with the absence of comorbidities necessary to access this treatment, in addition to the current shortage of donors. About 2,200 HT scan performed per year in the United States and 250–300 HT per year in Spain[4,5]. For a long time, HT list has been the basis for the development of various mechanical circulatory support devices (MCS).

In recent years, both short-term and long-term ventricular assist devices (VADs) have developed greatly; currently, its indication is well defined as abridging therapy to recovery, bridge to HT, bridge to decision, bridge to candidacy or destination therapy (**Table 1**).

Table 1. Indications for mechanical circulatory support

Bridge to decision/bridge to bridge	Short-term MCS is used in patients with cardiogenic shock to stabilize hemodynamic parameters and target organ perfusion to evaluate other treatments, such as long-term MCS or HT.
Bridge to candidacy	Use MCS to improve perfusion, reverse pulmonary hypertension, or provide cancer-free time to make HT qualified.
Bridge to Transplant	Due to the high mortality of patients before HT, left ventricular or biventricular assist is used to maintain the survival of patients.
Bridge to recovery	Left ventricular or biventricular assist is used to maintain patient survival until ventricular function is restored.
Destination therapy	Long-term MCS in end-stage HF ineligible for HT.

MCS: Mechanical circulatory support. HT: Heart transplant. HF: Heart failure.

2. History

In 1953, the modern era of cardiac surgery began. Cardiopulmonary bypass was first used for the rehabilitation of patients with cardiogenic shock after cardiac surgery, which laid a foundation for the further development of VADs[6]. By the 1960s, simple VADs began to replace cardiopulmonary bypass to treat this very serious heart disease. The use of implantable artificial ventricles, including a pneumatic device, was first reported in 1963[7] to connect the left atrium (LA) to the descending aorta to provide 4-day partial ventricular support during postoperative cardiac surgery. In 1966, Debakey successfully used the first pneumatic VADs for 10 days in postoperative heart surgery[8]. In 1969, it was reported that the whole artificial heart was used as a bridge to connect HT[9]. After these events, people have been looking for simple and lasting implant devices for decades. In the 1970s, the first generation of extracorporeal pneumatic VAD appeared, which could remain in place for a few days due to the high rates of hemolysis and thrombosis, with high costs and low effectiveness as pump. In 1984, Novacor successfully implanted its electric pulse device into the left ventricle as a bridge for transplantation[10]. In 1985, Jarvik 7 artificial heart successfully realized the first HT bridge. Since then, the so-called assists era of first generation, all with pulsatile flow, but only three subtypes have been approved by the U.S. Food and Drug Administration (FDA) as a bridge to transplantation:

(1) Left intracorporeal support type, being the first to demonstrate its effectiveness was Thoratec IP LVAS in 1995, a pneumatic device; subsequently, the HeartMate VE/XVE with electric pulsating plate was launched.

(2) Univentricular or biventricular support paracorporeal devices, neumatic such as the

Thoratec PVAD.

(3) Devices of artificial heart type, such as Cardiowest, currently known as Syncardia. After the publication of REMATCH, pulse technology showed its advantages over medical treatment. After 12-month follow-up, the mortality was reduced by 48% at the expense of high rate of complications of VADs[11].

The focus of the second-generation device is on smaller size, lower complication rate and higher durability, so that it can be used as the destination therapy or bridge to transplantation. Continuous and axial flow pumps have emerged, such as Jarvik 2,000, Heart Assist 5 or Incor from Berlin Heart. The HeartMate II was approved as a bridge to transplantation in 2008 and as a destination therapy in 2010 with obvious advantages compared with other pulse devices[12,13]. In recent years, the third-generation ventricular assist device has developed, continuous type devices, but of the centrifugal type. Among different devices, the HeartWare intrapericardial plant is the most prominent, and was approved by FDA in 2012 as a bridge to transplantation.

The latest device designed was the HeartMate III with pulsatility.

About short-term MCS, its development focuses on fast and simple implants, because in acute situations, stabilization is needed as a bridge to decision, recovery, implantation of a long-term dvice or HT. They have a more limited role and less evidence as a bridge to transplant indication. Some of the most used are Abiomed AV and BVS 5,000 pulsatile and extracorporeal type, but the support time is less than 10 days. Others, such as Thoratec PVAD or Excor Berlin Heart, were born as long-term devices and are currently classified as short-medium devices. The latest development in this field is CentriMag, which allows univentricular or biventricular support in piossible combined with ECMO (ExtraCorporeal Membrane Oxygenation: Extracorporeal membrane oxygenation).

3. Type of ventricular assist device

The purpose of different VADs is to restore tissue perfusion and increase blood supply; however, their management may be a challenge, as well as the recognition of various complications that may occur with its use, some of which pose a threat to life. Therefore, according to different indications, treatment doctors must be familiar with different types of equipment, understand its mechanism, related physiology and the identification and treatment of complications.

Depending on its indication, VADs can be implanted as a paracorporeal or extracorporeal device (located outside the patient's body) or intracorporeally. The latter can be located in the pericardial space or under the diaphragm, or it can be a percutaneous type; regardless of the shape or location of the implant, all currently available systems have external controllers and power supplies[14].

They can be classified according to the support they provide: left ventricular (LV), right ventricular (RV), or biventricular support. For patients with little residual cardiac function and low recovery opportunities, complete artificial heart may be an option to completely replace the function of natural heart.

The most common way to classify VAD is based on their usage time[15]:

Short term: hemodynamic support for days or weeks.

Percutaneous: Intra-aortic balloon counterpulsation, IMPELLA®, TANDEM-HEART®.

Surgery: ECMO-VA, CentriMag.

Long term: hemodynamic support, which can be extended for months to years.

INCORE, EXCOR, HeartMate I, HeartMate II, HeartWare, HeartMate III.

3.1. Short time left ventricular assist device

Over the past few decades, these devices have gained a place in supporting patients with cardiogenic shock refractory to medical treatment; as well as during high-risk surgery, such as percutaneous revascularization or arrhythmia ablation.

When ventricular support methods are properly selected and applied, it can effectively help as a bridge to recovery, bridge to bridge or HT. These devices can assist the left or right ventricle and, in some cases, provide biventricular assistance. Although their most common indication is not advanced HF, they can be safely used in acute events of this group of patients, in their stabilization and used until the decision of a more lasting therapy (bridging to decision or destination treatment) or they can serve to optimize the patient prior to implantation of a long-term equipment or performing HT (bridge to bridge or bridge to HT).

Intra-aortic balloon counterpulsation

Although its effectiveness in cardiogenic shock is controversial[16], whether as a bridge of recovery or to HT, it is still a widely used treatment because of its higher availability compared with other MCS devices. Its implants are less complex, less invasive and have a low risk of complications. It can improve cardiac function by reducing afterload and improving myocardial oxygen demand. Its main disadvantage is its inability to partially or completely replace cardiopulmonary function.

It consists of a cylindrical balloon located in the descending aorta near the left subclavian artery and connected to the external pump and console through a flexible catheter (**Figure 1**). The concept of diastolic counterpulsation includes balloon inflation during relaxation, balloon deflation in early contraction during isovolumic contraction[17], increasing coronary flow, decreasing left ventricular afterload, reducing myocardial oxygen consumption, increasing cardiac output and reducing parietal stress.

Its hemodynamic effect depends on: the volume of the balloon, the parameters programmed on the console, the position in the aorta, the relationship between the balloon size and the aorta, heart rhythm and heart rate, so its hemodynamic effect can be variable. However, there is sufficient evidence that in patients with cardiogenic shock, systolic blood pressure decreased by 20%, diastolic blood pressure increased by 30%, average pulmonary artery pressure decreased by 23%, and cardiac output increased by 20–24%. Improving tissue perfusion and reducing myocardial oxygen consumption is one of its most important roles[18]. Complications were rare (0.5%), including lower extremity and renal ischemia. The mortality associated with the device is less than 0.05%.

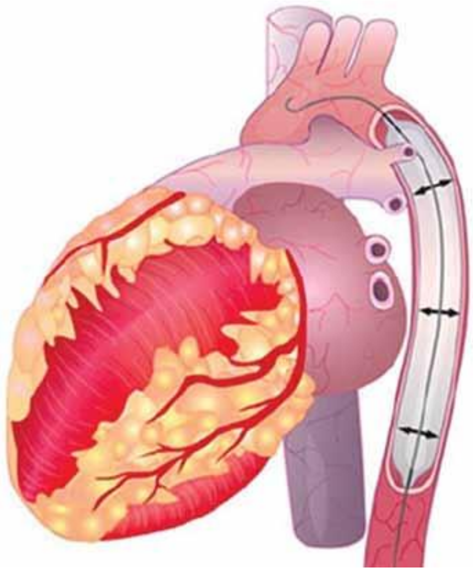

Figure 1. Schematic diagram of intra-aortic counterpulsation balloon.

Impella system (ABIOMED Inc.)

This is an axial flow system on a catheter that positioned through the aortic valve (**Figure 2**). The inflow port is located inside the left ventricle and the outflow port is in the aorta. In this way, it reduces ventricular pressure by providing non-pulsatile flow to the ascending aorta. There are several types of thrusters: 2.5 (2.5 L/minute of flow), CP (3.5 L/minute of flow), 5.0 (5 L/minute of flow), all of which can be used for percutaneous femoral implantation[19]. Contraindications to implantation include moderate or severe aortic stenosis or dysfunction, presence of ventricular septum defects, left ventricular thrombosis, or significant peripheral arterial disease[20].

The most common complications are limb ischemia, vascular injury, bleeding requiring blood transfusion and hemolysis. There was no significant difference between the safety of ambos and that of intra-aortic counterpulsation balloon[21].

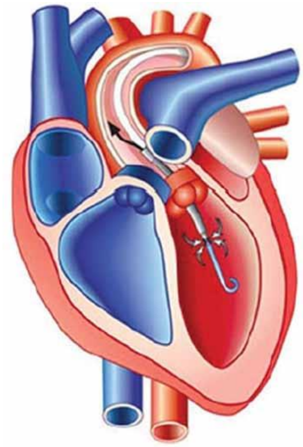

Figure 2. Schematic diagram of propulsion system.

Tandem cardiac system® (cardiac assist)

An external centrifugal pump system has a cannula with an inlet flow at the LA level and a cannula with an outlet flow at the femoral artery level (**Figure 3**). Oxygenated blood pumped into the femoral artery in this way can provide cardiac output of 3.5 to 4.5 L/min. The need for percutaneous puncture increases the risk and complexity of implants. The most common complications are cardiac tamponade, lower limb ischemia, arrhythmias, and persistent septal defects that may require subsequent closure[22].

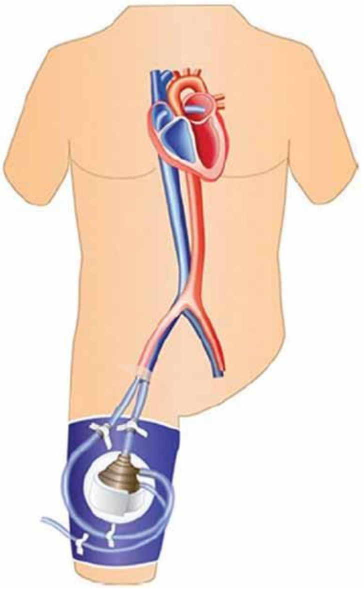

Figure 3. Schematic diagram of series cardiac system.

Extracorporeal membrane oxygenation (ECMO)

It has been available since 1972 to support heart and lung function because deoxygenated blood is extracted from the body through the cannulas system and then returned to the systematic circulation through the oxygenator. The oxygenator is a gas exchange device that directly oxygenates while removing carbon dioxide from the blood. Blood flow is generated by centrifugal pumps with high blood velocity, generating the least possible trauma to blood components[20], providing continuous, non-pulsatile flow of up to 3.5–4.5 L/min and extracorporeal oxygenation.

If blood is extracted from the central vein and returned to the venous system, the process is called venous-venous ECMO (ECMO-VV); If blood is extracted from the venous system and returned to the arterial system, it is called venous-arterial ECMO (ECMO-VA). In the first case, only respiratory support was provided, while the second is used for cardio-respiratory and in cases such as cardiogenic shock (**Figure 4**). The most common complications include massive hemorrhage, cerebrovascular accident, embolic phenomena,, infection and multiple organ dysfunction (**Table 2**):

ECMO-VA: This VAD mode intubation can be performed in the center or periphery. During central intubation, blood is discharged directly from RV and returned to aorta, while during peripheral intubation, blood flow is discharged from venous system (femoral vein or jugular vein) through surgery or Seldinger technology and returned to arterial circulation through carotid artery, axillary artery or femoral artery intubation[23].

ECMO-VV: partial or total lung support is preferred when treating severe respiratory failure and maintaining cardiac function. Both drainage and return tubes are located in the venous system.

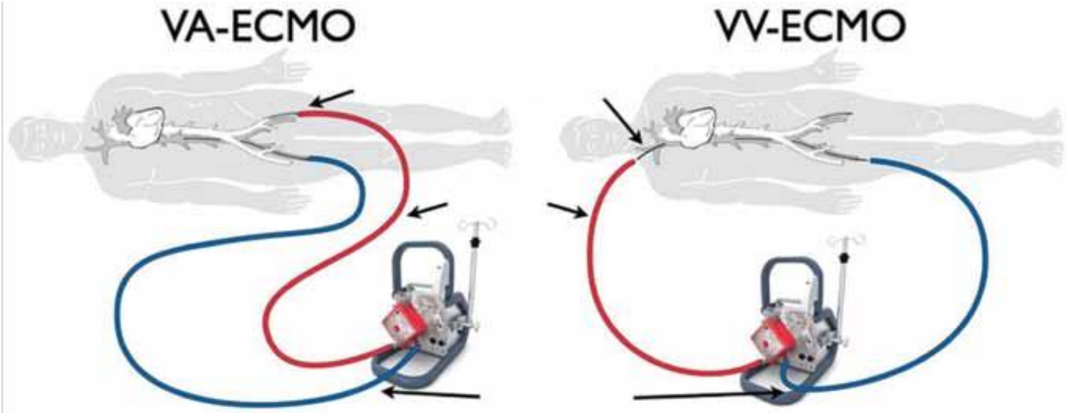

Figure 4. Schematic diagram of extracorporeal membrane oxygenation system: ECMO-VV and ECMO-VA[23].

Table 2. Differences between ECMO modes

Venous artery ECMO	Venous venous ECMO
Achieve higher PaO_2 levels	Reach lower PaO_2 level
Lower infusion rate is required	High perfusion rate
Exclude pulmonary circulation	Maintain pulmonary blood flow
Decreased pulmonary artery pressure	The level of PO_2 in mixed venous blood increased
Provides cardiac support and assists systemic circulation	It provides neither cardiac support nor systemic circulation, and only Requires intravenous intubation
Requires arterial cannulation	Intravenous intubation only

ECMO: ExtraCorporeal membrane oxygenation: extracorporeal membrane oxygenation.

CentriMag®

It is an extracorporeal centrifugal pump used for surgical implants and can provide blood flow of up to 10 L/min (**Figure 5**).

Figure 5. A representative of CentriMag.

This is a third-generation continuous pump with magnetic levitation rotor. It has the least friction, thus reducing the shear force between red blood cells and hemolysis. It has been approved as a support for the left and right ventricles, placing a cannula with inflow at the level of the LV or RV and with the outflow cannula at the level of the aortic or pulmonary artery level, respectively[25]. **Table 3** summarizes the contraindications and application of short-term VAD.

3.2. Long term ventricular assist device

Definition

The following definitions are important for understanding the operation and programming of the different devices currently available:

Pump speed (revolutions per minute): determine the speed of the pump flow, and it is programmed in each device according to the patient and medical standards.

Pump flow (L/min): The device flow is directly proportional to the rotor speed and inversely proportional to the pressure difference between the pump inlet and outlet cannulae; therefore, in addition to the reduction in revolutions per minute, the reduction in flow may be caused by various conditions that reduce VAD preload (intravascular volume reduction, RV failure, blockage, inlet cannula blockage).

Table 3. Short-term ventricular assist device

Device	Contraindication	Complication
Intra-aortic balloon counterpulsation	Moderate to severe aortic insufficiency. Aortic dissection. Abdominal aortic aneurysm	Thrombocytopenia. Thrombosis, aortic dissection or rupture. Gas embolism.
ECMO	Mechanical ventilation > 7 days.	Circuit thrombosis. Gas embolism. LV dilatation.
Centrimag	Active bleeding.	Thromboembolic events. Gas embolism.
TandemHeart	Ventricular septal defect. Moderate to severe aortic insufficiency. Contraindications to anticoagulation.	Casing displacement. Cardiac tamponade. Thromboembolism. Atrial septal defect.
Impella	LV thrombus Moderate to severe aortic valve disease. Recent TIA/ACV. Contraindications to anticoagulation.	Hemolysis. Device migration. Aortic insufficiency. Ventricular arrhythmia. Cardiac tamponade.
All MCSs	Severe peripheral arterial disease. Sepsis. Contraindications to anticoagulation	Bleeding. Vascular injury. Infected. Nerve injury.

ECMO: Extracorporeal membrane oxygenation. LV: Left ventricle. VAD: Ventricular assist device. TIA/CVA: Transient ischemic attack/cerebrovascular accident.

Pump power: It is a measure of the energy and voltage applied to the motor, which changes with the speed and flow of the motor.

Pulsatibility index: Corresponds to the magnitude of the flow through the pump, it gives the approximate value of the cooperation between LV and the generated flow. It fluctuates with the changes of heart volume and contractility, and the higher the pulsatility, the greater the ventricular preload or contractility.

Device types

Currently available VAD are divided into three generations according to their development sequence and the type of pumping mechanism used:

(1) First generation or pulsatile flow devices: They were the first to be developed, also known as positive displacement pumps. They are characterized by their large size for patients with medium body surface area. In the design, different parts are exposed to the risk of mechanical failure (valves, inlet and outlet pipelines, etc.). Effectively evacuate the left ventricle and maintain system circulation, with a pumping capacity of up to 10 L/min. Examples of these VAD include: HeartMate I or XVE and Novacor VAD. They were surgically implanted in a pocket under the rectus abdominis or in front of the peritoneum and connected to the left ventricle and ascending aorta[26]. In most studies that assessed the maximum support duration has not exceeded 6 months, most were between 50–60 days[27].

(2) Second generation or continuous (axial) flow devices: Much smaller, longer lasting and less complex to implant compared with the first generation. Examples of these devices include: HeartMate 2 VAD (Thoratec Inc.), Jarvik 2000 (Jarvik Heart Inc., New York), Micromed Debakey VAD and Berlin Heart Incor (Berlin Heart AG). The only moving part of the VAD is the rotor, so its durability

is higher. Its use requires both antiplatelet and anticoagulant therapy. HeartMate 2 is the second generation of VAD mainly targeted. It was approved as a bridge for transplantation by FDA in 2008 and destination therapy in 2010.

(3) Third generation or continuous flow (centrifugal) device: Small VAD, the rotor is suspended by magnetic force. Examples of this group of devices are HeartWare and HeartMate III. They are all intracardiac implants, so they do not need to be re implanted into the abdominal cavity or preperitoneal pocket.

Table 4 describes the characteristics of long-time VAD, and **Figure 6** shows schematic diagrams of different long-time VAD.

Table 4. Characteristics of long-term VAD

Device	Disegno	Operation	Pulsatility	Location of	Weight (g)	Maximum flow (L/min)
HeartMate II	Axial	Mechanical	No	Preperitoneal/intraperitoneal	281	10
Jarvik 2000	Axial	Mechanical	Yes	Pericardium	90	7
Incor	Axial	Hydrodynamic	No	Pericardium	200	8
HeartWare	Centrifugal	Hydrodynamic	No	Pericardium	145	10
HeartMate III	Centrifugal	Magnetic	Yes	Pericardium	200	10

VAD: Ventricular assist device

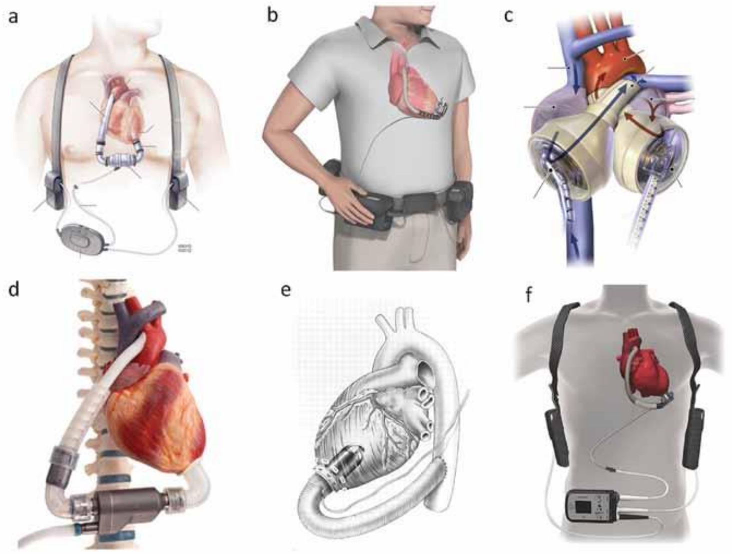

Figure 6. Schematic diagram of long-term ventricular assist device: **a**. HeartMate II LVAD (Thoratec Inc.). **b**. HeartWare LVAD (HeartWare Inc.). **c**. SynCardia total artificial heart. **d**. INCOR (Berlin Heart; Berlin, Germany) and Jarvik, 2000. **f**. HeartMate III (Thoratec Corp)

Patient selection

Candidate patients for MCS are patients with previously defined advanced HF. This definition covers a wide range of patients with different clinical manifestations, severity and prognosis, which is why the INTERMACS group has developed a seven-stage classification to sub-classify these patients (**Table 5**).

For patients with INTERMECS 1 and 2 characteristics, long-term VAD implantation should be avoided because of its low survival rate; instead, they should be considered as short-term equipment. The INTERMACS 3 group was the patient who benefited the most from long-term VAD.

Table 5. Classification in 7 stages of patients-INTERMACS profile descriptions

Profile	Description	Characteristics	SCM Type
1	Critical cardiogenic shock	Life-threatening hypotension and the rapid increase in the demand for pressor drugs, insufficient perfusion of key organs, acidosis and deterioration of lactic acid concentration.	Short-term VAD or ECMO-VA
2	Progressive deterioration	Organ function impairment, despite intravenous muscle strength support, is characterized by deterioration of renal function, lack of nutrition and inability to restore volume balance.	Short-term VAD or LVAD
3	Stable but inotrope dependent	Stability of blood pressure, organ function, nutrition and symptoms, continuous intravenous muscle strength support (or VAD), but repeated attempts to withdraw from treatment due to hypotension or renal insufficiency.	LAVD
4	Symptoms at rest with oral home treatment	Daily symptoms of congestion. The dosage of diuretics fluctuates greatly. Consider more rigorous treatment strategies and monitoring. It can oscillate between profile 4 and 5.	LAVD
5	Intolerable movement	He is very comfortable at rest, but he is unable to engage in any activities and can only stay at home.	Consider LAVD
6	Limited exercise capacity	Comfortable at rest, no signs of water overload, able to carry out some minor activities. Activities of daily living are very comfortable. You can visit friends or go out to dinner, but you will be tired in a few minutes.	Consider LAVD
7	NYHA III advanced function class	Clinically stable, with a reasonable level of comfortable activity, with a history of decompensation that is not recent. You can walk more than one block. Any decompensation requiring intravenous diuretics or hospitalization in the last month falls into profile 6.	Not consider LAVD

INTERMACS: Interagency Registry for Mechanically Assisted Circulatory Support (NYHA): Interinstitutional registry of mechanically assisted circulatory support. VAD: Ventricular assist device. LVAD: Long-term ventricular assist device.
NYHA: New York Heart Association.

ROADMAP 28 evaluated long-term VAD treatment compared with optimal drug treatment in outpatients and heart failure patients who did not rely on muscle strength therapy (INTERMACS curve ≥4). After one year of follow-up, the survival rate and functional status of patients receiving ventricular care were significantly improved; however, adverse events doubled in this treatment group. The HeartMate II risk score is designed to predict the risk of candidate patients with long-term VAD implantation, whether as a target treatment or as a bridge to HT. Different factors were identified as: Hypoproteinemia, renal failure, experience of implantation center and patient age were risk factors for 90 day mortality[29].

In the eighth annual report of INTERMACS, more than 20,000 patients with long-term VAD implantation in more than 180 hospitals were reported[30]. 2,500 devices are implanted each year. In 18,987 cases of implanted LVAD, more than 90% were continuous.

Since 2013, both centrifugal pump and axial flow pump have been put into use. About 50% of the devices are implanted as treatment targets, 26% represent patients waiting for HT examination, and 23% represent patients with bridging strategy. Since 2008, the proportion of patients implanted with VAD during cardiogenic shock has stabilized at 14–16%, of which the largest proportion is patients with contour 3 (stable but requiring muscle strength), accounting for 38% of all implants. Profiles 4 to 7 (considered outpatient CI) have decreased to 12.8% of total implants (**Table 5**).

Clinical evidence

As devices become more durable, portable, and easier to program, and the use of targeted therapy becomes more and more common, long-term

VAD was initially evaluated as a bridge to HT in waiting patients. **Table 6** summarizes the main clinical studies that evaluated the survival of these devices[31].

Table 6. Published clinical studies of left ventricular assist devices

Anal study	N	Device	Instructions	Research design	Patient population	Result
EMATCH, 2001[11]	129	HeartMate XVE	DT	Prospective 1:1 HeartMate XVE vs medical therapy	Patients with CF IV (NYHA) for 60 days, LVEF <25%, peak oxygen consumption <14 ml/min/kg (unless on counterpulsation ball, IV inoculum or physically unable to perform exercise test), or intra-aortic counterpulsation ball or IV inotrope-dependent or intra-aortic balloon pump for 14 days	Survival of 52% and 23% with 1 and 2 years with HeartMate XVE vs 25% and 8% with medical therapy
INTREPID, 2007[31]	55	Novacor	DT	Non-random prospective	Inotrope-dependent patients	Survival of 27% with 1 year with Novacor vs 11% with medical therapy
HeartMate II, 2009[12]	192	HeartMate II	DT	Prospective randomized 2:1 HeartMate II vs HeartMate XVE	In the past 60 days, patients with CF IIIB or IV (NYHA) have more than 45 days, LVEF <25%, maximum oxygen consumption <14 ml/min/kg (unless they have a balloon counterpulsation, inotropes, IV or physically unable to perform exercise testing), or intra-aortic balloon pump or IV inotrope-dependent for 14 days	Survival of 68% and 58% with 1 and 2 years with HeartMate II vs 55% and 24% with HeartMate XVE
HeartMate II post approval, 2014[31]	247	HeartMate II	DT	Non-random prospective	Consecutive patients eligible for DT in INTERMACS	Survival of 74% and 61% with 1 and 2 years with HeartMate II
HeartMate II, 2007[33]	133	HeartMate II	BTT	Non-random prospective	Transplant candidates	75% survival to transplant, recovery or continued support, although still eligible for transplant at 6 months
HeartMate II post approval, 2011[31]	169	HeartMate II	BTT	Non-random prospective	Consecutive patients eligible for transplantation at INTERMACS	90% survival to transplant, recovery or continuous support at 6 months
Advance, 2012[34]	137	HVAD	BTT	Non-random prospective HVAD Compared with 499 patients receiving FDA-approved HVAD at INTERMACS	Transplant candidates	90.7% survival to transplant, recovery or continuous support with the original device vs 90, 1% in the control group at 6 months

N: Number of patients. CF: Functional class NYHA: New York Heart Association. BTT: Bridge to transplant. DT: Destination therapy. LVEF: Left ventricular ejection fraction IV: Intravenous injection. FDA: Food and drug administration. HVAD: HeartWare Ventricular Assist Device NTERMACS: Interinstitutional Registry of Mechanical Circulatory Assistance support. INTREPID: Investigation of transplant ineligible patients who are inotrope dependent. LVAD: Left ventricular assist device. REMATCH: Randomized evaluation of mechanical assistance for the treatment of heart failure. ADVANCE: Evaluation of the HeartWare ventricular assist device for the treatment of advanced heart failure

The REMATCH 11 study, published in 2001, is the cornerstone for determining the benefits of long-term VAD treatment in patients with advanced heart failure, although this study shows that the improvement of beyond phase VI, durability and the incidence of complications associated with heart disease XVE are below optimal levels. Subsequent studies of continuous flow devices (HeartMate II and HeartWare) showed significant benefits in survival between the ages of 32 and 34. In 2010, the FDA approved HeartMate II and began to expand destination therapy in 2012. Since 2012, the number of implants used for this purpose has exceeded the bridging indications of TC 30. In a prospective, non-randomized study, 10 centers from Europe, Australia and Canada reported the latest evidence of the third-generation device (HeartMate III). In this preliminary trial of 50 patients, the researchers reported a 92% survival rate without stroke or device replacement[35]. A study is currently under way to compare the non-inferiority of HeartMate III and HeartMate II as graft bridges or destination therapies.

4. Complications of long-term VAD

4.1. Thrombosis

In these patients, one cause of the low cardiac output state is device thrombosis, which occurs in about 8% of the implanted continuous flow VAD[36], blocking the input and output cannulas. Thrombosis can occur in the same device or can be dragged from another place into the same device[37]. This may occur even in patients who are correctly anticoagulated and antiplatelet due to the chronic hypercoagulable state caused by VAD. The thrombosis of the device can be manifested as cardiogenic shock, and the rough noise generated by the thrombus in the device can be recognized. At the laboratory level, the increase of LDH level can be demonstrated by strong hemolysis. Chest X-rays may show the wrong location of inlet and outlet catheters, or signs of pulmonary congestion with decompensated heart failure. On Doppler echocardiography, left ventricular dilatation, severe mitral insufficiency and frequent aortic valve opening indicate insufficient flow, and this diagnosis should be suspected[38]. Anticoagulant therapy, fibrinolytic therapy, equipment replacement or HT optimization can be considered as emergency treatment.

4.2. Acute right ventricular failure

It occurs in 5~10% of patients after long-term VAD implantation[39]. Suspicious factors of Doppler echocardiography include impaired right ventricular dilation and systolic function, tricuspid insufficiency and reduced tricuspid annulus offset. In right heart catheterization, pulmonary artery pressure and central venous pressure increased, and pulmonary artery pressure was normal. In terms of treatment, muscle strength drugs such as dobutamine, milrinone or norepinephrine take effect quickly. If medication does not improve symptoms, the right short-term VAD implant should be considered as a rapid propulsion or tandem heart until recovery, or as a bridge to the VD long-term auxiliary implant[40].

4.3. Gastrointestinal bleeding

The reported incidence of complications ranged from 22% to 40%[41]. It is speculated that the cause of this common complication is the change of blood flow pattern, especially the lack of continuous flow device and acquired von Willebrand factor. The pattern of minimal or zero opening of the aortic valve in these patients is similar to those with severeaortic stenosis (Heyde syndrome), resulting in abnormal pulse curve, insufficient intestinal perfusion, dilation of the submucosal venous plexus of the gastrointestinal tract, resulting in vascular dysplasia, arteriovenous malformations and bleeding.

4.4. Infection and sepsis

The infection rate of continuous flow equipment is lower than that of pulse equipment; nevertheless, the infection rate remains a common complication (30–50% of implant devices)[42]. VAD patients, as an indication of targeted therapy, are more likely to be infected than HT bridges because they tend to be older, more advanced and take longer ventricular care. The diagnosis and treatment of sepsis are the same as those of the general population.

5. Conclusions

HT is still the best treatment for patients with advanced heart failure; however, due to the global donor shortage and long waiting list, given the quality of life of patients with this serious disease, the increasing development and use of VAD has improved short-term and long-term survival, resulting in a gradual reduction in the rate of complications. These benefits not only provide a choice for patients waiting for HT, but also give those with reversible contraindications the time and opportunity to become suitable candidates or, if impossible, eventually use it as a target treatment. However, these devices have many limitations: their cost, durability, incidence of complications and their limited application. Technological advances in mitigating complications, increased experience in management centers, and their promotion to reduce costs will continue to strengthen the use of VAD in patients with advanced heart failure.

Conflict of interest

The author declares no conflict of interest.

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